DISEASES OF THE EYE

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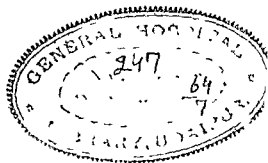104 GLOUCESTER PLACE
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EFACE TO THE TENTH EDITION

ent advances in the methods of prod   tion of local and
l anæsthesia, of immobilisation of the site of operation
ve-block, and in operative technique have necessitated
lrastic revision of these subjects in this edition   A
t section has been devoted to anæsthesia and nerve
giving precise instructions according to the best modern
· for ophthalmic surgery   I have not entirely eliminated
the simpler operative procedures, since these are often
satisfactory in selected cases, and should be employed
inners or in the absence of up to date equipment and
issistants   I have, however, added descriptions of
c erations, e g , of cataract, involving greater difficulties
ore refined technique   In all these matters I have had
able help from Mr H B Stallard— so much indeed
is only fitting that his name should appear upon the
oge

re have also been some outstanding advances in thera
, especially with regard to vitamins and sulphonamides
o im the success of the treatment of puerperal fever by
nul unide bids fair to be rivalled by the revolution of the
ient of ophthalmia neonatorum by sulphapyridine, and
r bacterial infections by the appropriate sulphonamides

ist th   b   has received careful revision throughout,
effort has been made to retain its character as a reliable
action to the diseases of the eye for students, general
ors and junior ophthalmic surgeons

<div align="center">J HERBERT PARSONS</div>

DISEASES OF THE EYE

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DISEASES OF THE EYE

SECTION I

ANATOMY AND PHYSIOLOGY

CHAPTER I

Anatomy

THE sensory nerves of the body are provided with end organs, by means of which they receive specific physical stimuli and transform them into nerve impulses The nerves of the special senses are no exceptions to the rule, and the eye is the highly differentiated and complex end organ of the sense of sight

The wall of the globe is composed of a dense, elastic supporting membrane (Fig 1) The anterior part of the membrane is transparent—the cornea, the remainder is opaque—the sclerotic The anterior part of the sclerotic is covered by mucous membrane—the conjunctiva—which is reflected from its surface on to the lids

The *cornea* consists of three layers. the epithelium, the substantia propria, and Descemet's membrane The epithelium, which is stratified, may be regarded as the continuation of the conjunctiva over the cornea proper It lies upon a homogeneous lamina of the substantia propria, called Bowman's membrane The substantia propria may be regarded as the continuation forwards of the sclerotic Descemet's membrane is a thin elastic membrane, covered on its posterior surface by endothelium . it may be regarded as the continuation forwards of the uveal tract. We shall see that the relationship of the three layers is of some pathological import-

hen, as is often the case, the cornea suffers second
ctival complaint the epithelium and superfi
ost likely to be affected : similarly, in disea
of the uveal tract the endothelium, Descen
orane, and the adjoining posterior layers of the
ntia propria.

The cornea is set into the sclerotic like a watch glass.
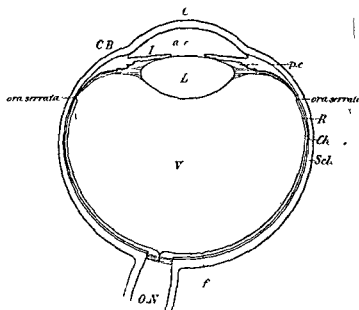
Fig 1 —Diagrammatic horizontal section of the eye. C, cornea,
a c, anterior chamber, I, iris, C B, ciliary body, p c, posterior
chamber, L, lens, V, vitreous, R, retina, Ch, choroid, Scl, sclero-
tic, f, fovea centralis, O N, optic nerve

the sclerotic overlaps the cornea all round the periphery. The
cornea is very richly supplied with nerve fibres derived from
the trigeminal. It has no blood vessels except for a fringe
of minute festoons, about 1 mm broad, at the periphery ;
the cornea is therefore dependent for its nourishment upon
diffusion of lymph, which is supplied from the conjunctival
vessels

Lining the sclerotic are two membranes : an outer, highly
vascular, concerned chiefly in the nutrition of the eye, and
comprising the greater part of the uveal tract ; and an inner,

nervous, the true visual nerve ending, concerned in the reception and transformation of light stimuli, and called the retina.

The uveal tract consists of three parts, of which the two posterior, the choroid and ciliary body, line the sclerotic while the anterior forms a free circular diaphragm, the iris. The plane of the iris is approximately coronal: the aperture

Fig. 2.—Angle of the anterior chamber. A, cornea; B, canal of Schlemm, which appears as several small spaces in the sclerotic just outside the ligamentum pectinatum iridis; it thus consists of irregular anastomosing venous channels which are cut across in the section; C, ciliary muscle; D, circulus arteriosus iridis major; E, iris; F, ciliary processes.

of the diaphragm is the pupil. Situated behind the iris and in contact with the pupillary margin is the crystalline lens.

The *anterior chamber* is a space filled with lymph, the *aqueous humour*; it is bounded in front by the cornea, behind by the iris and the part of the anterior surface of the lens which is exposed in the pupil. The sclerotic enters into the boundaries of the anterior chamber at the part which is known as the angle of the anterior chamber (Fig. 2). In the inner layers of the sclerotic at this part there is a network

of venous spaces which is called the *canal of Schlemm*   At the periphery, just anterior to the canal of Schlemm, Descemet's membrane splits up into fibrillæ, which are continuous with a meshwork of fibres stretching between the sclerotic and the iris, and known as the *ligamentum pectinatum iridis*   These fibres are covered by endothelium, which is continuous with that lining the cornea and also with that covering the iris   The spaces in the network of the ligamentum pectinatum iridis are called the *spaces of Fontana*   they are much better developed in lower mammals than in man   The tissue separating the ligamentum pectinatum from the canal of Schlemm is somewhat denser, and there is no free communication between the anterior chamber and the venous plexus, a thin membrane, covered on each surface by endothelium, being interposed   We shall see that a thorough knowledge of the anatomy of the angle of the anterior chamber is essential to the proper understanding of several pathological problems, especially that of glaucoma ✓

The anterior chamber is about 2 5 mm deep in the centre in the normal adult   it is shallower in very young children and also in old people

The *uveal tract* as already mentioned, consists of the iris, the ciliary body, and the choroid, from before backwards

The *iris* is composed of a stroma, consisting of branched connective tissue cells, usually pigmented, but unpigmented in blue irides, and containing a rich supply of blood vessels which run in a radial direction   The stroma is covered on its posterior surface by two layers of pigmented epithelium, which properly belong to the retina and are therefore called the *pars iridica retinæ*, or *pars retinalis iridis*   The anterior layer consists of flattened cells, which are very firmly attached to the stroma, the posterior of cubical cells, not so firmly attached to the anterior layer   Near the pupillary margin and concentric with it is a bundle of unstriped muscle fibres, the *sphincter iridis*   Associated with the anterior pigment epithelial cells there are fibres, arranged radially, which act as a *dilatator iridis*

The anterior surface of the iris is covered with a single layer of endothelium, except at some minute depressions or crypts which are found most at the ciliary border   Here the lymph spaces between the stroma cells communicate directly with the anterior chamber   this is probably a device for ensuring rapid transference of lymph from the iris to the anterior chamber and *vice versâ*, so as to facilitate quick movements of

the pupil in response to variations in the intensity of the light falling upon the eye The iris is thinnest at its attachment to the ciliary body, so that if torn it tends to give way here

The iris is richly supplied by sensory nerve fibres derived from the trigeminal, a fact which it is important to remember, since touching or cutting the iris, especially if it is inflamed, is intensely painful The sphincter iridis is supplied by motor nerve fibres derived from the oculomotor nerve, whilst the motor fibres of the dilatator iridis are derived from the cervical sympathetic nerve

The ciliary body in antero posterior section is shaped roughly like an isosceles triangle, with the base forwards The iris
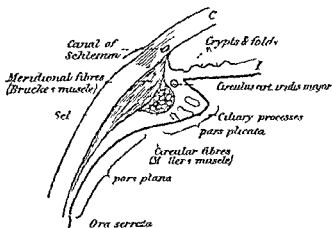
FIG 3—Diagrammatic meridional section of the ciliary body Note that the sclerotic overlaps the cornea as shown by the shading

is attached to about the middle of the base so that a small portion of the ciliary body enters into the posterior boundary of the anterior chamber at the angle (Fig 3) The chief mass of the ciliary body is composed of unstriped muscle fibres, the *ciliary muscle* This consists of two parts an outer, in contact with the sclerotic, consisting of antero posterior or meridional fibres, and an inner, consisting of fibres running at right angles to the former, arranged in a circle in the anterior part concentric with the base of the iris The meridional fibres can be traced far back, well into the choroid, and are inserted anteriorly into a "spur" of the sclerotic, traction upon which by the muscle is thought to open up the canal of Schlemm

If an eye is cut in half in an antero posterior direction and the inner surface of the ciliary body is inspected, it will be

noticed that the anterior part has a number of folds upon it,
while the posterior part is smooth The anterior part is there-
fore, called the pars plicata the posterior, the pars plana
If the plications are counted with the naked eye or under
slight magnification, it will be found that there are about
seventy in the whole circumference If microscopical sections
are examined, innumerable smaller plications and processes,
the *ciliary processes* will be seen upon the pars plicata These
contain no part of the ciliary muscle, but consist essentially
of tufts of blood vessels, not unlike the glomeruli of the kidney
They are covered upon the inner surface by two layers of
epithelium, which belong properly to the retina and are hence
called the *pars ciliaris retinæ* As in the pars indica retinæ,
the outer layer, corresponding with the anterior in the iris,
consists of flattened cells, the inner of cubical cells, but unlike
what obtains in the iris, they are not both pigmented, but
only the outer layer

The ciliary body extends backwards as far as the *ora serrata*,
at which point the retina proper begins abruptly , the transi-
tion from ciliary body to choroid, on the other hand, is gradual,
though this line is conveniently accepted as the limit of the
two structures The ora serrata is slightly more anterior on
the nasal than on the temporal side

The ciliary body is richly supplied with sensory nerve fibres
derived from the trigeminal, so that great pain results from
injury or acute inflammation The ciliary muscle is supplied
with motor fibres from the oculomotor nerve

The *choroid* is an extremely vascular membrane in contact
everywhere with the sclerotic though not firmly adherent to
it, so that there is a potential space between the two struc-
tures, which acts as a lymph space (Fig 4) On the inner
side the choroid is covered by a thin elastic membrane the
lamina vitrea or *membrane of Bruch* The blood vessels of the
choroid increase in size from within outwards so that imme-
diately beneath the membrane of Bruch there is a capillary
plexus the *choriocapillaris* Following upon this is the layer
of medium sized vessels, while most external are the large
vessels The vessels are held together by a stroma consisting
of branched pigmented connective tissue cells It is easy to
remember that the capillaries are innermost, because one of
the chief functions of the choroid is to nourish the outer layers
of the retina

The choroid is supplied with sensory nerve fibres from the
trigeminal.

The *retina* proper corresponds in extent with the choroid, which it lines As already mentioned however, and as shown by embryological research, it is continued forwards as a double layer of epithelium as far as the edge of the pupil If the two layers of epithelium are traced backwards, the anterior layer in the iris is found to be continuous with the outer layer in the ciliary body, and this again is continued into the hexagonal pigment epithelium, which covers the membrane of Bruch Similarly, the posterior layer in the iris, although pigmented, passes into the inner unpigmented layer of the ciliary body, and this suddenly changes at the ora serrata into the highly complex retina proper

The retina proper consists of a number of layers Most external, in contact with the pigment epithelium, is a neural epithelium, the rods and cones (Fig 4) Follow ing this, in order from without in wards, are the outer nuclear the outer reticular, the inner nuclear, the inner reti cular, the gang lion cell, and the nerve fibre layers

Fig 4 —Diagrammatic section of retina choroid and sclerot c at posterior pole of the eye   R re tina with *f* fovea centralis   *a* internal limit n̄ membrane, 1, nerve fibre layer 2 ganglion cell layer 3 internal reticular layer 4 internal nuclear layer   5 external reticular layer   6 external nuclear layer   *b* external limiting membrane 7, rods and cones   8 retinal pig ment epithel um. Ch choroid   *c* membrana vitrea or membrane of Bruch   9 choriocap llaris   10 layer of medium sized vessels or Sattler s layer   11 layer of large vessels or Haller s layer   Scl sclerotic with 12 lamina fusca on its inner surface

These *special nervous constituents* are bound together by neuroglia, the better developed vertical strands being called the fibres of Muller The *interlacement* of neuroglia fibrils on the outer side forms a sort of membrane which acts as a basement membrane for the rods and cones, the outer limiting membrane Similarly on the inner side the bases of Muller s fibres spread out and form an inner limiting membrane upon the inner surface of the nerve fibre layer Here the retina is in contact with the vitreous which is generally said to have an extremely delicate

bounding membrane, the hyaloid membrane   this is probably
only the denser outer layer of the vitreous gel, often modified
by reagents

At the optic disc the fibres of the nerve fibre layer pass into
the optic nerve, the other layers of the retina stopping short
abruptly at the edge of the porus opticus

At the posterior pole of the eye, which is situated about
3 mm to the temporal side of the optic disc a specially
differentiated spot is found in the retina of higher mammals
(man and monkeys) the *fovea centralis* As its name implies,
it is a depression or pit, and here only cones are present in the
neuro epithelial layer and the other layers are almost com
pletely absent The fovea is the most sensitive part of the
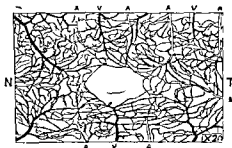
FIG 5 —Blood vessels in the macular region
of the human retina. (Nettleship) The
central gap corresponds with the fovea
centralis. N nasal side   T temporal
side A arteries V veins. The meshes
are much smaller than at the periphery of
the retina.

retina, and it is sur
rounded by a small
area the macula lutea,
or yellow spot, which,
though not so sensitive,
is more so than other
parts of the retina   It
is here that the nuclear
layers become gradually
thinned out, while on
the other hand parts
of the reticular layers
are specially in evi
dence   the ganglion
cells too instead of
consisting of a single
row of cells, are heaped

up into several layers   There are no blood vessels in the
retina at the macula so that its nourishment here is entirely
dependent upon the choroid (Fig 5) by way of compensation
the meshes of the capillary network of the choriocapillaris
are particularly small here

The so called *optic nerve* is really a lobe of the brain, and
therefore belongs properly to the central nervous system
Embryological and morphological investigations show that
the bipolar cells of the retina (the nuclei of which are in the
inner nuclear layer probably correspond with the cells in the
dorsal root ganglion of an ordinary sensory nerve (neurones of
the first order) Similarly the ganglion cells correspond
morphologically with the cells of the nucleus gracilis, or

part of the visual nervous mechanism which corresponds with an ordinary peripheral sensory nerve is a microscopic cell with its processes situated within the retina itself All the remainder is really part of the central nervous system, and we shall see that it responds to pathological processes more like the central than the peripheral nervous system

The *porus opticus* is the aperture in the sclerotic through which the optic nerve passes It varies much in shape in different cases, but in all it is traversed by a transverse network of connective tissue fibres containing much elastic tissue, the *lamina cribrosa* The fibres of the nerve fibre layer of the retina pass through the meshes of the lamina cribrosa and on the posterior side they suddenly become surrounded by medullary sheaths These nerve fibres, which comprise the greater number of the nerve fibres in the so called optic nerve, are the axis cylinder processes of the ganglion cells of the retina They are therefore afferent or centripetal fibres, but the optic nerve also contains a few efferent or centrifugal fibres

The *lens* is a biconvex mass of peculiarly differentiated epithelium It will be remembered that it is developed from an invagination of the epidermal epiblast of the fœtus so that what was originally the surface of the epithelium comes to lie in the centre of the lens, the peripheral cells corresponding with the basal cells of the epidermis Just as the epidermis grows by the proliferation of the basal cells, the old superficial cells being cast off, so the lens grows by the proliferation of the peripheral cells The old cells, however, cannot be cast off, but undergo change (sclerosis) analogous to that in the stratum granulosum of the epidermis, and become massed together in the centre or nucleus moreover the newly formed cells elongate into fibres, the lens fibres, which have a rather complicated arrangement Without going into details, it is important to bear in mind that the nucleus of the lens consists of the oldest cells and the periphery or cortex of the youngest Further, it must be pointed out that at an early stage the productive basal cells become limited to a single row of cubical cells covering the anterior surface The mass of epithelium which constitutes the lens is surrounded by a hyaline membrane, the lens capsule, which is thicker over the anterior than over the posterior surface (t p 49 Fig 48) it is a cuticular deposit secreted by the epithelial cells

The lens in fœtal life is almost spherical, it gradually becomes flattened so as to assume the biconvex shape It is

held in place by the suspensory ligament or zonule of Zinn.
This is not a complete membrane, but consists of bundles of
fibrils which pass from the surface of the ciliary body to the
capsule   The flattening of the lens is due to these fibrils
becoming more and more stretched as the eye grows   The
fibrils pass in various directions and the various bundles often
cross one another   Thus the most posterior arise from the
pars plana of the ciliary body almost as far back as the ora
serrata , these lie in contact for a considerable distance with
the ciliary body and then curve towards the equator of the
lens to be inserted into the capsule , most are inserted slightly
anterior to the equator   A second group of bundles springs
from the summits and sides of the ciliary processes, $i e$, far
forwards, and passes backwards to be inserted into the lens
capsule, slightly posterior to the equator   A third group passes
from the summits of the processes almost directly inwards to
be inserted at the equator

It will be noticed that there is a somewhat triangular space
between the back of the iris and the anterior surface of the
lens, having its apex at the point where the pupillary margin
comes in contact with the lens , it is bounded on the outer
side by the ciliary body   This is the *posterior chamber*   it
contains lymph of the same nature as the aqueous

Behind the lens is the large vitreous chamber containing
the *vitreous humour*   This is a jelly like material—in fact, it is
probably an inert structureless gel—containing a few cells and
wandering leucocytes   The fibres seen in histological sections
are probably artefacts except in pathological conditions   As
in other gels the concentration of the micellæ on the surface
gives rise to the appearance of a boundary membrane in
sections—the so-called hyaloid membrane

THE BLOOD SUPPLY OF THE EYE

The arrangement of the blood vessels which supply the eye
is peculiar and is of great importance in considering patho
logical conditions

The arteries of the eye in man are all derived from the
ophthalmic artery, which is a branch of the internal carotid
The ophthalmic artery has very few and insignificant anasto
moses so that on the arterial side the ocular circulation is an
offshoot of the intracranial circulation   This is not the case
to so marked a degree of the venous outflow of the eye   While
in man most of the blood passes to the cavernous sinus by

PLATE I
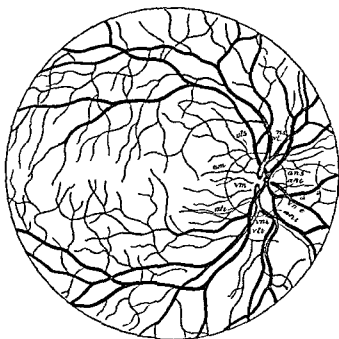
THE RETINAL VESSELS (after Leber)

a t s, superior temporal artery   *a n s*, superior nasal artery   *a t i*, inferior
temporal artery   *a n i*, inferior nasal artery   *a m*, macular artery
t t s, superior temporal vein   *v n s* superior nasal vein   *t t i*, inferior
temporal vein   *v n i*, inferior nasal vein   *v m*, macular vein

PLATE II.
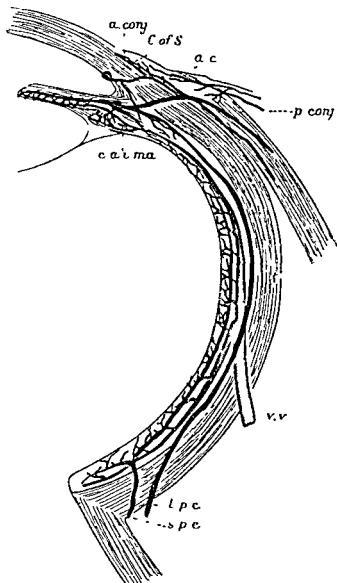
THE CILIARY SYSTEM OF VESSELS (after Leber).

p c short posterior ciliary arteries   *l p c*, long posterior ciliary artery
a c, anterior ciliary vessels   *C. of S*, canal of Schlemm   *c a i ma*,
circulus arteriosus iridis major   *v v*, venæ vorticosæ   *a conj*, anterior
conjunctival vessels   *p conj*, posterior conjunctival vessels.

way of the ophthalmic veins, yet it must be remembered that these anastomose freely in the orbit, the superior ophthalmic vein communicating with the angular vein at the root of the nose, and the inferior ophthalmic vein with the pterygoid plexus Hence too great stress must not be laid upon the circulation in the retina as a guide to the condition of the intracranial circulation, as has been done in the past

The retina is supplied by the central artery, which enters the nerve on its lower surface, 15—20 mm behind the globe The central artery divides on or slightly posterior to the surface of the disc into the main retinal trunks, which will be considered in detail later (Plate I) The retinal arteries are end arteries and have no anastomoses at the ora serrata The only place where the retinal system anastomoses with any other is in the neighbourhood of the lamina cribrosa The veins of the retina do not accurately follow the course of the arteries, but they behave similarly at the disc, uniting on or slightly posterior to the surface of the disc to form the central vein of the retina, which accurately follows the course of the corresponding artery

The uveal tract is supplied by the ciliary arteries, which are divided into three groups—the short posterior, the long posterior, and the anterior (Plate II, Fig 6) The short posterior ciliary arteries, about twenty in number, pierce the sclerotic in a ring around the optic nerve, running perpendicularly through the sclera, to which fine branches are given off The long posterior ciliary arteries, two in number, pierce the sclerotic slightly farther away from the nerve in the horizontal meridian, one on the nasal, the other on the temporal side They traverse the sclerotic very obliquely, running in it for a distance of 4 mm The anterior ciliary arteries are derived from the muscular branches of the ophthalmic artery to the four recti They pierce the sclerotic 5 or 6 mm behind the limbus or corneo scleral margin, giving off twigs to this region, to the conjunctiva and sclerotic

The ciliary veins also form three groups—the short posterior ciliary, the venæ vorticosæ, and the anterior ciliary The short posterior ciliary veins are unimportant, they do not receive any blood from the choroid, but only from the sclerotic The venæ vorticosæ are the most important, consisting usually of four large trunks which open into the ophthalmic vein They enter the sclerotic rather behind the equator of the globe, two above and two below they pass very obliquely through the sclera The anterior ciliary veins are smaller than the

corresponding arteries, since they receive blood only from the *outer part of the ciliary muscle*

Of these ciliary vessels the short posterior ciliary arteries supply the whole of the choroid, being reinforced anteriorly
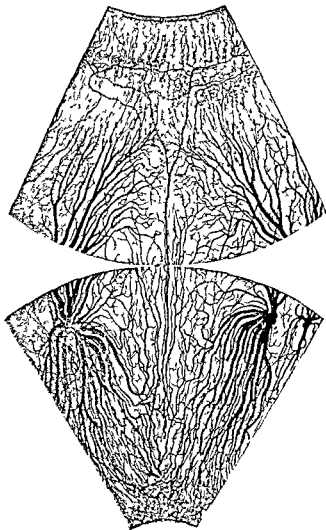
Fig 6 —Blood vessels of the human uveal tract, injected, from the optic disc to the edge of the iris   (After Leber)   Arteries, black ; veins, paler   Running up the centre is a long posterior ciliary artery Two vorticose veins and their tributaries are seen.   The capillaries are only partially filled in

by anastomosis with recurrent branches from the ciliary body The ciliary body and iris are supplied by the long posterior and anterior ciliary arteries The blood from the whole of the uveal tract, with the exception of the ciliary muscle, normally leaves the eye by the venæ vorticosæ only

The two long posterior ciliary arteries pass forwards between the choroid and the sclerotic, without dividing, as far as the posterior part of the ciliary body Here each divides into two branches (Fig 6) they run forwards in the ciliary muscle, and at its anterior part bend round in a circular direction, anastomosing with each other and thus forming the *circulus arteriosus iridis major* This is situated in the ciliary body at the base of the iris from it the ciliary processes and iris are supplied Other branches from the major arterial circle run radially through the iris dividing dendritically and ending in loops at the pupillary margin A circular anastomosis takes place a little outside the pupillary margin, the *circulus arteriosus iridis minor*

The tributaries of the vorticose veins, which receive the whole of the blood from the choroid, are arranged radially the radii being bent, so as to give a whorled appearance—hence their name The veins of the iris are collected into radial bundles which pass backwards through the ciliary body, receiving tributaries from the ciliary processes Thus rein forced, they form an immense number of veins running backwards parallel to each other through the smooth part of the ciliary body After reaching the choroid they converge to form the large anterior tributaries of the vorticose veins The veins from the outer part of the ciliary muscle on the other hand pass forwards and unite with others to form a plexus, part of which is the so-called canal of Schlemm These vessels drain into the anterior ciliary veins The marginal loops of the cornea and the conjunctival vessels are branches of the anterior ciliary (Plate II.).

CHAPTER II

Physiology

IN order that the eye may satisfactorily perform its duties as an organ of vision it is essential that a sharp image of objects in the outer world shall be formed upon the retina This is effected by means of a series of curved surfaces, and the curvature of these surfaces and their relative positions to each other must be kept constant For this purpose it is necessary that the walls of the globe should be kept stretched

If a small canula connected with a narrow bored mercury manometer is pushed into the anterior chamber or into the vitreous of an animal it will be found that the mercury in the manometer will rise about 25 mm (Fig 7) In other words, the contents of the eyeball, which are for the most part fluid, exert a pressure upon the inner side of the walls which is about 25 mm of mercury greater than than the atmospheric pressure which falls upon the outside of the walls, the walls are thus kept well stretched

This pressure inside the eye is called the intraocular pressure, or the *tension*, of the eye (These terms are used indiscriminately, though it is not quite accurate to do so) It is obvious that it must be the fluid constituent of the contents of the globe which keeps up the internal pressure   This fluid fills the anterior and posterior chambers and permeates the vitreous   It is comparable to the lymph which bathes the tissues in other parts of the body, and it is indeed the lymph of the eye   In other parts of the body the chief function of the lymph is to carry food material to the tissue cells, and to carry away the effete products of the cell metabolism   It has a further function of keeping up the normal tissue tension   Both of these functions attain an unusual degree of importance in the case of the eye   We have already seen the necessity for keeping up the normal tension of the eye As regards the nourishment of the cells, our review of the anatomy of the eye has shown that there are large areas, notably the whole of the lens and the vitreous, which possess

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no blood supply They are dependent entirely for their nutrition upon the lymph

If water were to be forced into an impermeable elastic bag, the internal pressure might be kept indefinitely above the pressure upon the outside of the bag Such an arrangement for keeping up the intraocular pressure would be unsatisfac
tory owing to the function
of the lymph in nutrition
The stagnant fluid would
soon lose all its food
material, which would be
used up, and it would be
come loaded with the ex
creted products of the cells,
which would have a very
deleterious effect upon
them Hence it is essential
that the lymph shall be
constantly renewed This
occurs in the eye The
lymph is continually being
renewed, but at the same

Fig 7 —Diagram of manometer placed in communication with anterior chamber showing that the normal intraocular pressure is about 25 mm of mercury

time it is equally rapidly being removed and thus the amount present is kept constant

Of recent years the views of physiologists on the formation of lymph in the different tissues of the body have undergone great modification It was natural that at first lymph formation should be regarded as a true secretion (Heidenhain) The typical example of secretion is the salivary gland Here it is possible by stimulation of secretory nerves to obtain saliva at a pressure far exceeding that of the highest local intravascular pressure The gland cells are doing work which cannot be accounted for by the ordinary physical laws of filtration and osmosis Evidence of secretory nerves for lymph formation in the eye, as elsewhere, has proved negative More over, it has been shown that the facts both experimental and pathological, are not inconsistent with explanation on purely physical, "biophysical" and biochemical grounds

Starling first produced definite evidence that lymph forma tion in the tissues could be explained by a simple process of filtration from the capillaries, the relations between the intra capillary and the lymph pressure, and the chemical constitu tions of the lymph being in accord with this view Leber arrived at the same conclusion with regard to the eye

The advances of biophysics and biochemistry, however, have shown that this view must be modified It has now been shown that many of the conditions of lymph production are consistent with the view that lymph is a simple dialysate from the blood plasma, and that the differences in constitution and pressure which obtain in different tissues may be due simply to the relative permeabilities of the dialysing membrane, _i e_, the capillary walls These results important as they are, do not of course solve the problem for it still remains to account for the varying permeability of the capillary walls

The experimental evidence in favour of the dialysation theory has been exhaustively determined for the eye by Duke Elder and others but further research has produced results antagonistic to this theory (Robertson) The fundamental fact is that the normal intraocular pressure, as shown by the manometer is from 20 to 25 mm Hg above the atmospheric pressure How is this brought about and maintained ? The most obvious source of energy is the blood pressure derived from the heart beat The first step is therefore to enquire into the hydrostatic conditions of the intraocular circulation The blood in the human eye is derived entirely from the internal carotid artery The pressure in this artery is very little less than that in the brachial artery—diastolic/systolic, 60–80/110–125 mm Hg The diastolic pressure in the ophthalmic artery can be measured in animals by increasing the intraocular pressure until the pulsation of the retinal arteries is maximal, the systolic by further increasing the pressure until the pulsation is abolished It is found to be diastolic/systolic, 60–70/95–115 mm Hg

The pressure in the intraocular arteries has been measured by introducing a micropipette containing methylene blue into a retinal artery by the aid of a micro manipulator, and ophthalmoscopic observation. The pipette is connected with a manometer and fluid is forced in until it just appears in the vessel Average pressures were diastolic/systolic, 64/88 mm Hg (Duke Elder)

Average results gave a mean fall of only about 10 mm Hg from carotid to ophthalmic artery, and of 25 mm Hg in the first branching in the eye, _i e_, 25 per cent of the total pressure The intraocular pressure shows a further fall of 54 mm Hg

In order that the circulation may be maintained it is clear that the lowest intraocular venous pressure must exceed the intraocular pressure The difference, measured by the micro

pipette, is only about 2 mm Hg (Duke Elder) A similar difference is found in Schlemm's canal

The blood vessels of the eye are subject to variations in calibre as in other parts of the body These are not merely passive as would be the case if the eyeball were a rigid closed box There is definite proof that the intraocular arterioles are under the control of vaso constrictor fibres derived from the cervical sympathetic, but there is no evidence of the existence of vaso dilator fibres Vaso motor changes, however, have been proved to be due to the liberation of substances which act upon the neuro myal junction In the case of sympathetic fibres the substance is adrenaline or a nearly allied substance, in that of the parasympathetic system acetyl-choline or an allied substance Vaso dilatation, however, can be brought about indirectly by antidromic impulses in sensory nerves (Bayliss) and by axon reflexes These lead to the liberation of histamine or an allied substance, which causes relaxation of the smaller vessels and capillaries

There is no means of measuring the intracapillary pressure within the eye directly The old view that variations in the calibre of the capillaries is passive owing to changes in the calibre of the arterioles has been profoundly modified by the researches of Krogh, Dale, Landis and others, who have shown that relatively enormous variations in capillary pressure occur, both rapidly and in neighbouring areas, and that these are brought about chiefly by dynamic changes in the size of the capillaries, probably effected by Rouget's cells and by local chemical changes due to acetylcholine or histamine The local effect of histamine, liberated by irritation of the fifth nerve endings, and the more distant effect due to axon reflexes (which is abolished by cocaine) have been proved to occur in the iris by Duke Elder Great variations in intracapillary pressure between the limits of 70-80 mm Hg (arterial) and 20-25 mm Hg (venous) are possible, and it may be that in some circumstances it rises as high as 50 mm Hg

Vaso dilatation produced by histamine cannot be counter acted by vaso constrictors such as adrenaline moreover, it causes marked increase in the permeability of the capillary walls, as evidenced by wheals in the skin, &c This increased permeability is of great pathological importance, accounting for plasmoid exudates in inflammatory conditions, &c it may be beneficial, opening the gate for the passage of immune bodies, all of which are large moleculed colloids, and some drugs (e g, arsenic compounds)

Manometric observations show that in general the intra
ocular pressure follows changes in the general blood pressure
passively (Fig 8)   Thus the large rises of blood pressure
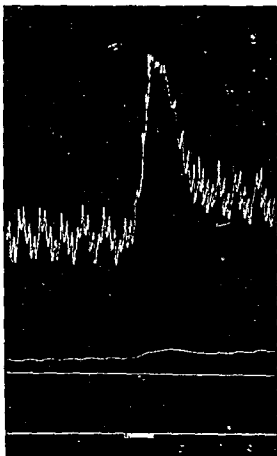
Fig 8   Tracing of right carotid blood pressure intraocular pressure
from canula in anterior chamber of left eye of a dog which was fully
under the influence of morphia A C E mixture and curare. Stimula
tion of the vasomotor centre showing that the intraocular pressure
follows passively all the changes in the general blood pressure as
produced by Traube Hering curves and constriction of the arterioles
of the splanchnic area.

produced by stimulation of the vaso motor centre, splanchnic
nerves asphyxia injection of nicotine or adrenaline, etc , are
reflected in the intraocular pressure curve   The parallelism,

however, is not absolute, as was shown long ago by the proof of the existence of vaso constrictor nerves and the local effects of adrenaline Perfusion experiments on the isolated head have revealed other local effects due to axon reflexes, chemical substances such as choline, histamine, drugs etc Probably most of these effects are due to changes in the capillary circulation

The intraocular fluid differs from lymph in other tissues of the body in its remarkable poverty in proteins In still greater degree does it differ thus from the blood plasma, but the differences are purely quantitative, all the constituents of the blood plasma being present in the aqueous The proteins are very much reduced (0 2 per cent as compared with 7 36 per cent in serum), much more so than in any other tissue lymph , but the relative proportions of globulin to albumin are the same as in the plasma Non dissociated diffusible substances, such as sugar, urea, etc , are equally partitioned between aqueous and plasma Dissociated diffusible substances, e g metallic salts, which are split up into electrically charged ions in solution are unequally distributed, the cations being in less and the anions in greater concentration in the aqueous The greater concentration of chlorides has long been known and should have attracted greater attention by the advocates of the filtration theory, since it militates against that theory It is however consistent with the dialysation theory, negatively charged ions being driven through the capillary membrane in order to maintain thermodynamic equilibrium with positively charged colloid ions (proteins) in the blood For the same reason the aqueous is slightly more acid than the plasma (pH 7 2 7 3) The plasma exerts an osmotic pressure of 20–30 mm Hg greater than the aqueous owing to the excess of non-diffusible colloids in it

What may be called the static intraocular pressure is therefore the resultant of the intracapillary blood pressure minus the difference between the osmotic pressures of aqueous and plasma (e g , 50 mm Hg − 30 mm Hg = 20 mm Hg) The intraocular pressure however is never static It follows passively normal changes in the blood pressure due to the pulse wave and respiration It undergoes large rises due to the activity of the extrinsic ocular muscles and the movements of the lids, especially of the orbicularis palpebrarum Large changes in the general blood pressure are accurately reflected in it except in so far as they are modified by local vasomotor or chemical effects If, however, the general changes persist as in cases of high blood pressure, compensation occurs and the

intraocular pressure resumes its normal level   Convection
currents are also set up in the anterior chamber owing to the
difference in temperature between the iris and cornea, the
aqueous moving upwards in front of the iris and downwards
behind the cornea   These currents can be seen with the slit
lamp (*vide* p 97) when, as is often the case, the aqueous
contains particles in suspension

The atomic and molecular changes which have already been
discussed are therefore associated with molar movements which
alter the local hydrostatic conditions   These are specially
marked under abnormal conditions   If the aqueous is
evacuated, *e g*, by paracentesis (*vide* p 209), the capillaries
dilate, the walls become more permeable and filtration of fluid
takes place   The fluid thus formed more nearly resembles the
blood plasma in containing more protein than the normal
aqueous   If again the eye is massaged the intraocular pressure
falls   Seeing that this pressure is dependent upon the volume
of the contents of the globe and the other conditions are not
materially altered the fall of pressure must be due to expulsion
of fluid from the eye   There is therefore some mechanism for
the filtration of fluid out of the eye   Cases of secondary
glaucoma (*vide* p 280) indicate the chief site of filtration out
of the eye, for in them the angle of the anterior chamber is
blocked   There can be no doubt that the rise in intraocular
tension which occurs in secondary glaucoma is due to blockage
of this filtration angle, whereby the aqueous is denied free
access to the canal of Schlemm

It has been shown that if the intraocular pressure is raised
so as to exceed that of the intravenous pressure, the veins
collapse   This results in a reflex rise of intravascular pressure
so that the circulation is restored   This process may in some
cases be repeated until the intraocular pressure equals the
arterial pressure, when the circulation stops   The canal of
Schlemm, however, is a venous channel in the substance of the
cornea and therefore does not collapse even when the intra
ocular pressure is moderately raised   Filtration can therefore
occur through its inner wall—unless the latter is rendered
impermeable by adherent iris, etc , an exit is thus provided for
the excessive fluid and the normal intraocular pressure is
restored   The meridional fibres of the ciliary muscle (*vide*
p 5, Fig 3) are inserted anteriorly into a scleral "spur," and
there is reason to think that when this muscle contracts in
accommodation it pulls this spur backwards, thus tending to
keep the canal of Schlemm open

The permeability of the capillaries is increased in inflammatory conditions, *e g*, iridocyclitis (*vide* p 255), and a plasmoid lymph, rich in protein, is formed   This causes a rise in intraocular pressure, and there can be little doubt that since in these cases the filtration angle is not otherwise obstructed and is indeed generally abnormally open the high tension is due to the difficulty of filtration of the large molecular colloid proteins into the canal of Schlemm

We may therefore conclude that both dialysation and filtration play their parts in the formation and disposal of the intraocular fluid and the maintenance of the intraocular pressure   They do not suffice to explain all the facts of normal and abnormal intraocular pressure   The dialysation theory alone has to fall back upon the variable permeability of the capillary walls in the various tissues of the body to explain the differences of lymph pressure and constitution , and this *variable permeability is at present only explicable on* teleological grounds

CHAPTER III

Elementary Optics

IT has already been stated that sharp images of external objects must be formed upon the retina if the latter are to be seen clearly Before considering how this is effected it will be advisable to refresh the reader's memory of the elementary principles of optics I would seriously impress upon the student that success in the diagnosis, and hence in the treatment, of diseases of the eye is impossible if such elementary principles of optics as are set forth here are not thoroughly mastered

If white light, such as sunlight, is passed through a suitable prism or diffraction grating a spectrum is formed, consisting of rays differing from each other in wave length Of these certain are visible and appear to the majority of people as pure colours viz , red, orange, yellow, green, blue, and violet in the order named, the red having the longest and the violet the shortest wave length The visible spectrum extends from about 723 $\mu\mu$ at the red end to 397 $\mu\mu$ at the violet end or roughly from 700 $\mu\mu$ to 400 $\mu\mu$ Beyond the red end are infra red rays of greater length which, when absorbed, cause a rise in temperature and are commonly known as heat rays Beyond the violet end are waves of smaller length the ultra violet rays which are capable of causing chemical action The longer visible rays also cause a rise in temperature, and the visible rays are also actinic, though less so than the infra red and ultra violet respectively Glass absorbs some of the heat rays and many of the ultra violet Prisms and lenses made of quartz allow most of the ultra violet rays to pass unimpeded The media of the eye are uniformly permeable to the visible rays between 660 $\mu\mu$ and 390 $\mu\mu$ With regard to ultra violet rays, the cornea absorbs all rays beyond 295 $\mu\mu$ the lens all rays beyond 3a0 $\mu\mu$, the vitreous shows an absorption band with its maximum at 270 $\mu\mu$ (E K Martin) Rays between 400 $\mu\mu$ and 295 $\mu\mu$ can therefore reach the lens those between 400 $\mu\mu$ and 350 $\mu\mu$ can reach the retina in the normal eye, and those between 400 $\mu\mu$ and 295 $\mu\mu$ can reach the retina in the aphakic eye Whenever absorption occurs there is the possibility of pathological changes resulting Sunlight at the lower sea levels is poor in ultra violet rays which fall off

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rapidly in intensity beyond 380 μμ   Ordinary glass used for
spectacles absorbs rays beyond 350 μμ   Heat radiation from
1,100 μμ to 700 μμ passes into the eye almost unchecked, and a
large amount of it reaches the retina (Hartridge and Hill)   The
pigment epithelium on the back of the iris absorbs heat radiation
of all wave lengths, and the same is probable of the retinal
epithelium at the back of the eye

It is a familiar fact that a candle flame emits light in all
directions   The light is transmitted in straight lines so that
we may imagine the light coming from the candle as consisting
of an immense number of straight lines, all intersecting in some
part of the flame   If we consider a minute point in the flame,
then all the straight lines which cross in this point may be
said to diverge from it   Each of these hypothetical straight
lines is called a ray

Now, every point on such a ray represents, or is the image
of, the point of light from which it springs   This is shown very
clearly by a simple experiment carried out in a dark room
Make a pinhole in a piece of cardboard (Fig 9, A) and hold
the cardboard in front of the candle (C) at a little distance
from it   Beyond the cardboard hold up a white screen (B) so
that the cardboard is between the screen and the candle   A
dim image (D) of the flame will be thrown upon the screen,
and it will be noticed that it is
upside down, i e , an inverted
image of the flame is formed.
This is due to the fact that the
cardboard cuts off all the rays of
light from the candle except such
as can pass through the hole   The
only rays from the top of the flame
which can pass through the hole
are those which are caught upon
the lower part of the screen
They represent the top of the
flame, hence they reproduce its
shape accurately   The image is very dim because only a few
rays of light can pass through the small hole   Now make
another hole a little distance away from the first   Another
inverted image of the flame is seen   If a dozen holes are
made, a dozen images appear   If two holes are very close
together the images will overlap   If a large hole is made, so
many images overlap that all resemblance to the original
flame is lost, and part of the screen becomes uniformly illu
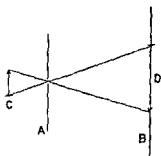
Fig 9

minated. If we take away the cardboard altogether the whole screen becomes illuminated, and we now know that *this* is because we have an infinite number of images of the flame all overlapping each other.

Light travels with different velocities in different media. If the velocity is less in one medium than another the first medium is said to be optically denser than the second.

When light, travelling in one medium, meets another medium it breaks up into two parts: part is *reflected* back into the first medium; part is *refracted* into the second medium. If the second medium is opaque none of the light is refracted.

REFLECTION

Let us now consider what happens to a ray of light when, travelling in one medium, it is reflected from the surface of a denser medium. We have already said that its direction is altered. Before it meets the surface it is called an *incident* ray; after it leaves the surface it is called the reflected ray. If a line is drawn at right angles to the surface at the point where the incident ray meets it, it is found to be an invariable rule that the incident ray makes the same angle with this line, which is called the normal, that the reflected ray makes with it. Put in formal language, this law of reflection *is that for all surfaces the angle of incidence is equal to the angle of reflection, and is in the same plane with it* (Fig. 10).

Fig 10 —The ray from P which strikes the mirror AB at Q is reflected to R, so that PQ and QR are in the same plane, viz, that of the paper, and the angle of incidence, i, is equal to the angle of reflection, r
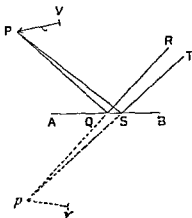
Fig 11

Plane Mirrors. Let us apply this rule to an ordinary flat mirror (Fig. 11). If P is a luminous point in front of the mirror AB, the ray PQ will be reflected towards R, and the ray PS towards T, *i e*, the reflected rays QR and ST appear to come

from p, a point as far behind the mirror as P is in front of it
As the rays QR and ST have to be produced backwards in order
that they may meet, no real image is formed, and such an
image is called a virtual image   Note that the rays reflected
from a plane mirror are divergent   The same reasoning holds
good for every point on the object PV, its image being pv as
far behind the mirror as the object is in front of it   moreover,
the size of the image is equal to that of the object

Concave Mirrors   Here the normal to the surface is the
radius of the sphere   If AH (Fig 12) is part of the section of
a concave mirror and PB is an object, K being the centre of
the sphere, then the line HKB is called the axis, and H the
apex of the mirror   The ray PK through the centre of the
sphere will obviously be reflected along itself, so that the image
of P must be on PK   The ray PA, parallel to the axis, will
meet PK in p Hence p is the image of P   Now it is found
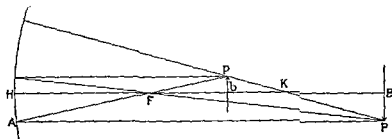
Fig 12.

that all rays parallel to the axis and not very far removed
from it cut the axis in the same point F, and this point bisects
the line HK   This point is called the principal focus of the
mirror   If the object PB were removed a very great distance
away from the mirror, all the rays which fell upon a small
portion of the mirror near H would diverge so little from each
other that they would all be practically parallel to BH, and
the image of PB would be extremely small and situated at F
In each of these cases the image is an inverted one of the object

It is an axiom of optics that the direction of the rays is
reversible   Hence, if pb were an object, it would have its
image at PB, and if there were an object at F, all the rays
from it reflected by the mirror would be parallel to the axis,
and the image would be infinitely large and situated at infinity

What would happen if the object were situated between
F and H?   In that case (Fig 13) the rays would diverge after
reflection as if they came from an object behind the mirror,

much as they do with a plane mirror   The image would there
fore be a virtual one, situated behind the mirror   it would be
erect and larger than the object

The important fact to remember with regard to concave
mirrors is that if the object is farther away from the mirror
than its focal distance, *i e*, than half its radius of curvature,
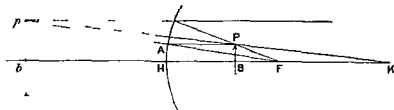
Fig 13 —The ray from P parallel to the axis is reflected through F, the
principal focus.   The ray FP is reflected parallel to the axis.   The
ray *h*P is normal to the surface and is therefore reflected on itself.
Any two of these rays will give the situation of *p*, the image of P

the image is a real inverted one situated also in front of the
mirror   This is the condition which is almost always present
in the ordinary use of ophthalmic instruments

Convex Mirrors   We are not accustomed to use convex
mirrors in ophthalmic instruments, but it is necessary to know
what happens with them, since the cornea acts as a convex
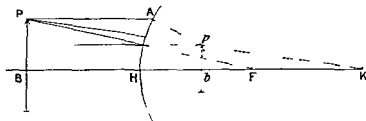
Fig 14 —Reflection by a convex mirror   The description of Fig 13
applies equally to this case.

mirror   Here, as will be seen from Fig 14, the image is always
virtual, erect, and smaller than the object   As with the con-
cave mirror, if the object is a long way off, the image will be
situated at the principal focus   *i e*, at a distance equal to half
the radius of curvature behind the mirror.

REFRACTION

We have now to consider what happens to the refracted ray
when the incident ray, travelling in one medium, *e g*, air,

meets an optically denser medium, e g, glass We have already said that the light will now travel more slowly It follows directly from this fact that it will be deviated towards the normal to the surface, and it will be more deviated the greater the difference in optical density between the two media If the density of air is taken as unity, then the ratio of its density to that of the second medium is called the *index of refraction* of the medium

Plane Lamina Let us see what happens when an incident ray, such as PQ (Fig 15), meets the surface of a plate of glass with parallel sides It will be deflected towards the normal, ab When the ray passes out of the glass on the other side, it will obviously be deflected away from the new normal, cd, just as much as PQ was

Fig 15—Refraction by a plane lamina

deflected towards it Hence the emergent ray RS will be parallel to the incident ray PQ If the plate of glass is very thin, RS will be practically continuous with PQ

Prisms If we imagine one side (CD) of the plate in the last figure to revolve round R, we shall be able to understand the nature of refraction by a prism QR will now make a larger angle with the new normal ef than it did with the old one cd Consequently the angle of refraction will also be larger, i e, the new direction of the emergent ray will be
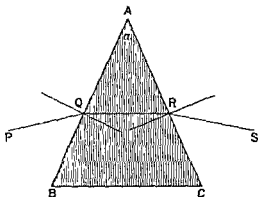
Fig 16—Refraction by a prism

RT. In other words, the ray is deviated towards the base of the prism

The ray PQRS in Fig 16 is said to pass symmetrically

refracted in such a manner that they all cross the axis in a single point upon the other side of the lens This point is called the principal focus of the lens, and its distance from the lens is called the focal distance or length of the lens When the lens has the same medium, e g , air, on each side of it, the
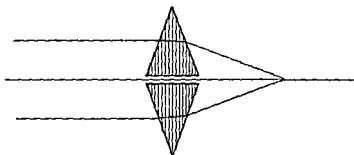
Fig 19

two principal foci, one on each side of the lens, are situated at equal distances from it For thin glass lenses of low power the focal distance is equal to the radius of curvature of the two surfaces when these are equally curved If there is an object a very long distance away from the lens, the rays which come from it are practically parallel Hence in this case an image of the object will be formed by the lens at its principal focus ,

Fig 20 —The ray PE parallel to the axis is refracted through the second principal focus F₂ The ray PF₁, through the first principal focus, is refracted parallel to the axis The ray PO, through the optical centre of the lens is not deflected Any two of these rays give the situation of p, the image of P

it will be inverted and very small If the object is gradually brought nearer and nearer to the lens (Fig 20) the image will recede farther and farther from it, from being very small it will grow larger and larger, until, when the object is at the principal focus, the image will have receded to infinity, and it will be infinitely large, i e , all the rays coming from the object

through the prism In these circumstances if the prism
is made of crown glass the deviation of the ray is approxi
mately equal to half the refracting angle of the prism a

Prisms are numbered according to the angle of the prism
(°) or preferably according to the actual deviation (△) e g
a 4° prism is approximately the same as a 2° prism

We are accustomed to project objects along the direction of
the rays of light as they enter the eye and in doing so we
ignore the effect of refraction since it enters relatively little
into our everyday experience If therefore we look at a
candle P through a prism as in Fig 17 the light will appear

to come from p
Objects then seen
through a prism,
appear displaced to
wards the apex of
the prism

Lenses Ordinary
lenses are pieces of
glass with spheri
cal surfaces The
line passing through
the centres of cur
vature of the sur
faces is called the
axis of the lens
Fig 18 shows the
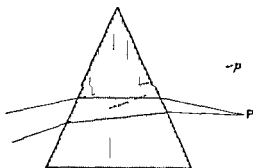
Fig 1 —Displacement of objects seen through
a prism The object P appears to be situated
at p

chief varieties of lenses viz (1) biconvex (2) biconcave
(3) plano-convex (4) plano-concave (5) convexo-concave or
meniscus these names require no further explanation

The effect of a biconvex lens upon rays of light meeting it

Fig 18 —Types of lenses.

is very similar to what would occur if it were replaced by two
prisms set base to base (Fig 19)

If the incident rays are parallel to the axis they will be

be deviated , the ray PE parallel to the axis will pass through the second principal focus F_2 , and the ray PF_1 through the first principal focus will be parallel to the axis after refraction Hence pb must be the image of PB

The effect of a biconcave lens upon rays of light meeting it
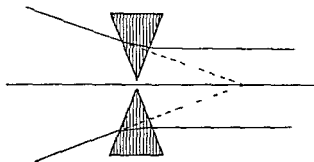
Fig 23

is very similar to what would occur if it were replaced by two prisms set apex to apex (Fig 23)

Here, if the incident rays are parallel to the axis they will be divergent after refraction, and the amount of divergence of the individual rays will be such that if they are produced backwards they will all cross the axis in a single point upon the same side of the lens that they came from This and the
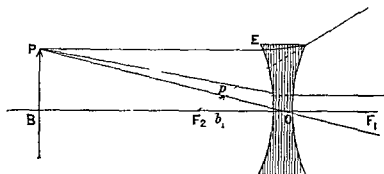
Fig 24 —The description of Fig 20 applies equally to this figure

corresponding point on the other side of the lens are called the principal foci The biconcave lens also has an optical centre, situated upon the axis within it and having the same properties as in the case of the convex lens The image of any object formed by a concave lens can be constructed in exactly the same manner as for a convex lens (Fig 24) It will be found that in every position of the object the

at the principal focus are parallel to the axis and to each other after refraction   If the object is brought still closer to the lens than its focal distance (Fig 21) it will be found that its image is a virtual one behind the object, and that it is erect and larger than the object   The positions of the object and image bear a constant relationship to each other and are called conjugate foci

There is a point in the middle of a biconvex lens which is
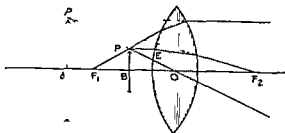
Fig 21—The description of Fig 20 applies equally to this figure

called its optical centre   With thin lenses any ray which passes through this point is practically not deviated at all   It is easy to understand why this is so   If PQRS (Fig 22) is such a ray and tangents are drawn to the two surfaces at the points Q and R, these two tangents will be parallel to each
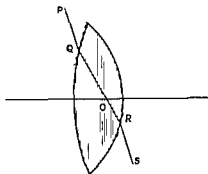
Fig 22—Properties of the optical centre of a lens.

other   Consequently, the lens acts for such a ray exactly as if it were a plate with parallel sides, and we have already seen that in such a case the emergent ray is parallel to its original direction   If the lens is very thin the refracted ray will be practically continuous with the incident ray

If we know these facts viz., that rays passing through the optical centre are not deviated and that rays passing through the principal focus are parallel to the axis after refraction we can easily construct the image of an object in any given position   Thus in Fig 20 if PB is an object the ray PO through the optical centre O will not
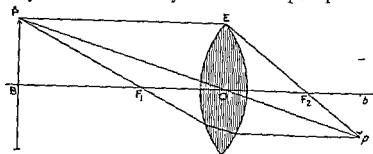
be deviated, the ray PE parallel to the axis will pass through
the second principal focus F_2, and the ray PF_1 through
the first principal focus will be parallel to the axis after
refraction   Hence pb must be the image of PB

The effect of a biconcave lens upon rays of light meeting it

Fɪɢ. 23.

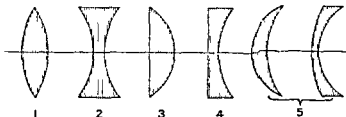is very similar to what would occur if it were replaced by two
prisms set apex to apex (Fig 23)

Here, if the incident rays are parallel to the axis they will
be divergent after refraction, and the amount of divergence
of the individual rays will be such that if they are produced
backwards they will all cross the axis in a single point upon
the same side of the lens that they came from   This and the

Fɪɢ 24 —The description of Fig 20 applies equally to this figure

corresponding point on the other side of the lens are called
the principal foci   The biconcave lens also has an optical
centre situated upon the axis within it and having the same
properties as in the case of the convex lens   The image of
any object formed by a concave lens can be constructed in
exactly the same manner as for a convex lens (Fig 24)
It will be found that in every position of the object the

image is always virtual, erect and smaller than the object Plano convex and plano-concave lenses act like biconvex and biconcave respectively, but in them the optical centre is on the curved surface at the point where the axis cuts it. The Menisci act as convex or concave lenses according as the convex or the concave surface has the greater curvature   In them the optical centre is outside the lens

It will have been noticed that the refractive power of a lens varies inversely as the focal distance, i e , a lens with a short focal distance will bend the rays more than one with a longer focal distance   It is necessary to have some system of numbering lenses so as to indicate their refractive power   The most convenient system for ophthalmic purposes is that which takes a lens with a focal distance of 1 metre as a standard   Such a lens is said to have a refractive power of 1 *dioptre*   A lens with a focal length of half a metre will be twice as strong as one whose focal length is 1 metre   the refractive power of such a lens is therefore 2 dioptres   Similarly, a 3 D (3 dioptre) lens has a focal length of one third of a metre, or 33 cm , a 4 D lens, 25 cm   and so on   It is important to remember that in this system the standard is a metre, not a centimetre or a millimetre , otherwise confusion may arise

Lenses were formerly numbered according to their focal lengths measured in inches   Since the inch has a different value in different places, the method is unsatisfactory   Prescriptions for spectacles are, however, sometimes met with in this notation They are easily transformed into the dioptric system by remembering that there are 40 inches (roughly, or 36 Paris inches) in 1 metre   Therefore a 40 inch lens = 1 D , a 20 inch lens = 2 D , a 4 inch lens = $\frac{40}{4}$ = 10 D   and so on   a lens of focal length = 4 Paris inches = $\frac{36}{4}$ = 9 D

Convex lenses are indicated by a plus sign (+), concave by a minus sign (−) before the number

Cylindrical lenses are also used in ophthalmology , their nature and use will be considered at a later stage

We often wish to find out whether a lens is convex or concave, and what its refractive power is   There are several ways of doing this, but the simplest is with the assistance of the trial case   Hold a convex lens up near the eye and look at distant objects through it , then move the lens a little from side to side   the distant objects will seem to move in the

opposite direction to that in which the lens is moved If we repeat the process with a concave lens the objects seem to move in the same direction as the lens The reason is to be found in the fact that a convex lens forms an inverted, whilst a concave forms an erect, image If we place two lenses of opposite sign but equal curvature in contact with one another the combination will make a plate with parallel sides such a plate, as we know, *does not practically deflect the rays of light at all* Hence we can determine the strength of a lens by exactly neutralising it with a lens of the opposite sign out of the trial case Let us take a concrete example, a particular lens which we wish to determine We hold it up and find that distant objects seem to move in the opposite direction to the lens

FIG 25

We know that it is a convex lens We then put a weak concave lens in contact with it and repeat the process We find that with a − 2 D lens objects still seem to move in the opposite direction, though not so much With a − 3 D lens there is only a trace of movement, and with a − 3 5 D lens there is no movement at all We conclude that the original lens was + 3 5 D In performing this test it is important to have the two lenses as closely in contact as possible, and also
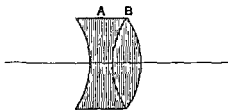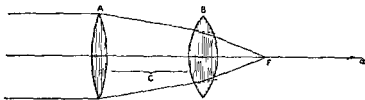
Fig 26

to have their centres in contact (Fig 25) If the centre of one lens is higher than that of the other they will obviously not counteract each other exactly If they are not in contact the result will be either too high or too low

When the lenses are in contact the refractive power of the combination (*D*) is equal to the algebraical sum of the refractive powers of the two lenses (d_1, d_2) i e, $D = d_1 + d_2$, or $\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2}$, where F, f_1, f_2, are the respective focal distances (Fig 26)

Suppose, however, that two convex lenses are separated by a distance c (Fig 26) The lens A will make parallel rays converge towards a, but after a distance c they meet the lens B hence the convergence of the rays is not expressed by $\frac{1}{f_1}$, but by $\frac{1}{f_1 - c}$ Therefore the combined effect of the lenses, D, or $\frac{1}{F}$, is now equal to $\frac{1}{f_1 - c} + \frac{1}{f_2}$

If the second lens (B) is a concave one (Fig 27) its effect will
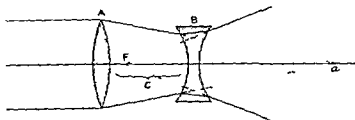
Fig 27

be one of divergence, so that it must have a negative sign and D will now be equal to $\frac{1}{f_1 - c} - \frac{1}{f_2}$

It is to be noted that in the formula

$$\frac{1}{F} = \frac{1}{f_1 - c} + \frac{1}{f_2}$$

F is now the posterior focal length the incident light impinging upon the lens whose focal length is f, and being directed towards the lens whose focal length is f_2 The following formula gives the equivalent focal length (F_e) of the combination, irrespective of the direction of light —

$$F = \frac{f_1 f_2}{f_1 + f_2 - c}$$

Examples   (1) $f_1 = 333$ mm , $f_2 = 250$ mm $c = 133$ mm

Then $\frac{1}{F} = \frac{1}{333 - 133} + \frac{1}{250} = \frac{1}{111}$

That is the combination of a $+ 3$ D lens with a $+ 4$ D, separated by a distance of 133 mm , will be that of a $+ 9$ D lens instead of a $+ 7$ D if they had been in contact

(2) $f_1 = 333$ mm $f_2 = -83$ mm $c = 133$ mm

Then $\frac{1}{F} = \frac{1}{333 - 133} - \frac{1}{83} = -\frac{1}{142}$

That is, the combination of a $+ 3$ D lens with a $- 12$ D, separated by a distance of 133 mm , will be that of a $- 7$ D lens, instead of $- 9$ D if they had been in contact

CHAPTER IV

Elementary Physiological Optics

The eye as an optical instrument very much resembles an ordinary photographic camera. The latter consists of a dark chamber with an aperture in front containing a strong convex lens, and with a movable back behind. The effect of the lens is exactly like that shown in Fig 20. PB will represent the object to be photographed; the movable back is adjusted so that it occupies the position of pb, in which case a sharp image of the object will be thrown upon the ground glass which forms the back. The ground glass is then replaced by a sensitive plate, and the photograph is taken.

In the eye the retina corresponds with the sensitive plate. Instead of having only one lens in the front aperture, represented by the crystalline lens, there is also a curved plate with parallel sides, the cornea, which acts like another lens, and indeed has a much stronger optical effect than the crystalline lens. The object of this more complicated arrangement is to shorten the focal distance of the system, so that the eye may be shorter and more compact.

From this analogy we see that the eye, from the optical point of view, acts like a strong convex lens. We have already stated that when a lens has the same medium on each side of it the anterior and the posterior focal distances are equal to one another. This is not the case in the eye. Here the medium in front is air, while behind the lens there is the vitreous, which has a higher refractive index, rather more than that of water. Hence the anterior and posterior principal focal distances are not equal, the anterior being about 13 mm in front of the cornea, and the posterior about 23 mm behind it.

The cornea has about the same optical density or refractive index as the aqueous, which is also equal to that of the vitreous. The anterior surface of the cornea may be regarded as nearly spherical, the radius of curvature being 8 mm. The centres of curvature of the cornea and the two surfaces of the lens are all on the same straight line, which is called the optic

axis When a ray of light meets the cornea (Fig 29) the ray will be deflected towards the normal, *i e*, towards the radius drawn through the point of incidence It will pass through the layers of the cornea in the new direction, and will also continue in the same direction through the aqueous, for, as we have said, the refractive index of the aqueous is the same as that of the cornea When the ray meets the lens, which has a greater refractive index than the aqueous, it will again be deflected in the same sense, *i e*, towards the axis upon which the cornea and lens are centred

The eye approximates to a homocentric optical system, *i e*, one composed of a series of spherical surfaces whose centres lie on a common *axis* The geometrical properties of such a system may
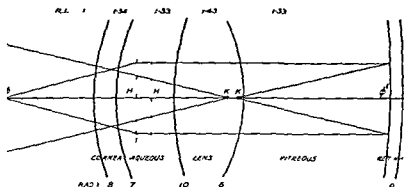
FIG 28 —THE CARDINAL POINTS OF THE EYE

φ, The anterior principal focus in front of the cornea
φ', The posterior principal focus upon the retina
H, H, the principal points, in the anterior chamber
K, K', the nodal points, in the posterior part of the lens
R.I Refractive indices

be much simplified by considering them to possess three pairs of *cardinal points* or *planes* Rays passing through either *principal focus* emerge from the system, after refraction, parallel to each other A ray directed through one *nodal point* emerges, after refraction, through the second *nodal point* and parallel to its original direction A ray passing through any point on one *principal plane* emerges, after refraction, as though it came from the corresponding point on the second *principal plane*, but the incident and emergent rays are not usually parallel to each other

Since the principal and nodal points in the eye are very close to each other no great error is introduced by fusing them into a

ingle principal point at the point where the axis cuts the cornea
and a single nodal point in the posterior part of the lens (*e g*,
Fig 30)

We have seen that in the case of a lens, and the same is
true of any homocentric optical system, parallel rays meet at
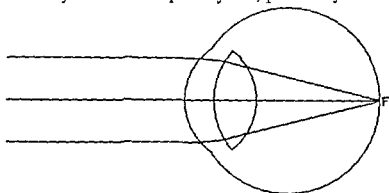
Fig. 29.—Emmetropic eye   Parallel rays are brought to a focus
on the retina.

the principal focus   Hence, if parallel rays fall upon the
cornea, they will be brought to a focus 23 mm behind it
Now, the rays which are emitted by a luminous body are
divergent   If, however, the object is a long distance away,
the individual rays in any small bundle will diverge so little
from each other that they may be regarded as practically
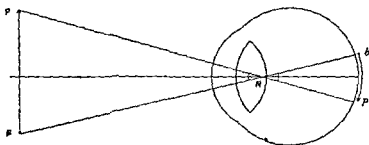
Fig 30.—Nodal point of the eye, visual angle, and relative sizes
of object and retinal image

parallel   This is the case with the small bundles of rays which
are able to enter the pupil of the eye   Hence, as in the case of
a convex lens (*vide* p 29), the image formed by the eye of these
distant objects will be situated at the principal focus, i e,
23 mm behind the cornea   But that is exactly the distance of

the retina from the cornea in the normal eye Hence we see
that the normal eye in its condition of rest is so constituted
that distant objects form their images upon the retina (Fig 29)

The optic axis, produced backwards to meet the retina, cuts
it almost exactly at the fovea centralis Hence, any distant
object on the prolongation forwards of the optic axis will
have its image at the fovea, which is the best spot for distinct
vision.

We notice that, just as with a convex lens, the image is
ted It is re-inverted psychologically in the brain
is easy to find the size of the retinal image which any
rnal object will form, since the eye possesses an optical
centre, which, however, is usually called the *nodal point* (N),
quite similar to the optical centre of the lens In the eye this
point is situated upon the optic axis near the back of the lens.

FIG. 31—Hypermetropic eye Parallel rays tend towards
a focus behind the retina.

As in the case of lenses, any ray which passes through this
point will not be appreciably deflected If, therefore, there is
an object PB (Fig 30) in front of the eye, the size of its retinal
image pb is found by joining the extremities of the object and
the nodal point and producing these lines until they meet the
retina The lines will enclose an angle, PNB, which is called
the visual angle, in other words, the angle subtended by the
object at the nodal point is called the visual angle It is of
course equal to the angle pNb, which is subtended by the
retinal image at the nodal point

In some eyes the retina is not situated in exactly the right
place for the images of distant objects to be clearly focussed
upon it It may be too far forward (Fig 31) or too far back
(Fig 32), in the former case they are said to be hyperme-
tropic, in the latter myopic If we consider the effect upon
parallel rays we shall see that in the hypermetropic eye they
have not had space to come to a focus, whereas in the myopic

eye they have not only come to a focus, but have commenced to diverge In each case a blurred image will be formed upon the retina, and vision will be impaired Such conditions are called errors of refraction or *ametropia* (ἁ, privative, μετροι, measure , not according to measure) In contradistinction to hypermetropia and myopia the normal condition is called emmetropia

It has already been stated that in optics the direction of the rays is reversible Let us imagine a minute point on the retina to be luminous It will give out rays which will diverge in all directions Some of these rays will meet the lens and cornea and pass out of the eye Now, in the emmetropic eye, those rays which get through the pupil will have to submit to exactly the same optical deviations as the parallel rays falling upon the cornea did when they passed into the eye and came

Fɪɢ 32—Myopic eye Parallel rays are brought to a focus in front of the retina

to a focus on the retina Hence, on the principle of the reversibility of the rays, the rays coming from a point on the retina will be parallel to each other when they leave the eye (Fig 29)

Suppose, however, that the eye is hypermetropic owing to being too short (Fig 33) The rays coming from a point on the retina will be relatively more divergent than the corresponding rays of the emmetropic eye before they fall upon the back of the lens (Compare the effect of placing an object closer to a convex lens than its principal focus (Fig 21) The lens and aqueous and cornea will therefore cause them to converge less than in the emmetropic eye They will therefore still be divergent when they leave the eye, though of course not so divergent as when they were passing through the vitreous In fact, their direction will be the same as if they came from a point behind the eye The nearer the

eye they have not only come to a focus, but have commenced to diverge In each case a blurred image will be formed upon the retina, and vision will be impaired Such conditions are called errors of refraction or *ametropia* (ἀ, privative, μετρον, measure , not according to measure) In contradistinction to hypermetropia and myopia the normal condition is called emmetropia

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FIG 32 —Myopic eye Parallel rays are brought to a focus in front of the retina.

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the retina from the cornea in the normal eye Hence we see
that the normal eye in its condition of rest is so constituted
that distant objects form their images upon the retina (Fig 29)

The optic axis, produced backwards to meet the retina, cuts
it almost exactly at the fovea centralis Hence, any distant
object on the prolongation forwards of the optic axis will
have its image at the fovea, which is the best spot for distinct
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We notice that, just as with a convex lens, the image is
inverted It is re-inverted psychologically in the brain

It is easy to find the size of the retinal image which any
external object will form, since the eye possesses an optical
centre, which, however, is usually called the *nodal point* (N),
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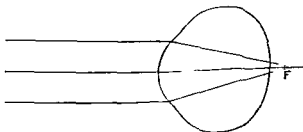point is situated upon the optic axis near the back of the lens

FIG 31 —Hypermetropic eye. Parallel rays tend towards
a focus behind the retina.

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point will not be appreciably deflected If, therefore, there is
an object PB (Fig 30) in front of the eye, the size of its retinal
image *pb* is found by joining the extremities of the object and
the nodal point and producing these lines until they meet the
retina The lines will enclose an angle, PNB, which is called
the *visual angle*, in other words, the angle subtended by the
object at the nodal point is called the visual angle It is of
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In some eyes the retina is not situated in exactly the right
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eye they have not only come to a focus, but have commenced to diverge In each case a blurred image will be formed upon the retina, and vision will be impaired Such conditions are called errors of refraction or *ametropia* (ά, privative, μετρον, measure , not according to measure) In contradistinction to hypermetropia and myopia the normal condition is called emmetropia

It has already been stated that in optics the direction of the rays is reversible Let us imagine a minute point on the retina to be luminous It will give out rays which will diverge in all directions Some of these rays will meet the lens and cornea and pass out of the eye Now, in the emmetropic eye, those rays which get through the pupil will have to submit to exactly the same optical deviations as the parallel rays falling upon the cornea did when they passed into the eye and came
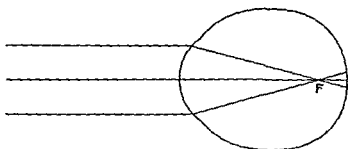

Fig 32.—*Myopic eye* Parallel rays are brought to a focus in front of the retina.

to a focus on the retina Hence, on the principle of the reversibility of the rays, the rays coming from a point on the retina will be parallel to each other when they leave the eye (Fig 29)

Suppose, however, that the eye is hypermetropic owing to being *too short* (Fig 33) The rays coming from a point on the retina will be relatively more divergent than the corresponding rays of the emmetropic eye before they fall upon the *back of the lens* (*Compare the effect of placing an object closer to a convex lens than its principal focus* (Fig 21)) The lens and aqueous and cornea will therefore cause them to *converge less than in the emmetropic eye* They will therefore still be divergent when they leave the eye, though of course not so divergent as when they were passing through the vitreous In fact, their direction will be the same as if they came from a point behind the eye The nearer the

retina is to the lens, the more divergent they will be, and the nearer to the back of the eye will be the point from which they seem to come This virtual point (R) behind the eye is called the *remote or far point* of the eye The point on the retina and this point behind the eye are really conjugate foci (Fig 33)
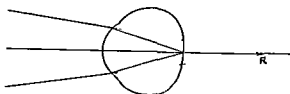
Fig 33—Hypermetropic eye Rays from a point on the retina are divergent when they emerge from the eye as if they came from the point R behind the eye

Suppose now that the eye is myopic owing to being too long (Fig 34) The rays coming from a point on the retina will be relatively less divergent than the corresponding rays of the emmetropic before they fall on the back of the eye (Compare the effect of placing an object farther away from a convex lens than its principal focus (Fig 20)) The refractive media in front will therefore cause them to converge more than in
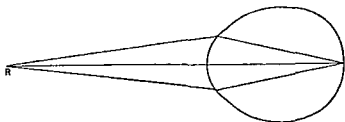
Fig 34—Myopic eye Rays from a point on the retina are convergent when they emerge from the eye so that they cross at a real point, P in front of the eye

the emmetropic eye They will hence be convergent when they leave the eye, and will cross in a point (R) somewhere in front of the eye (Fig 34) The farther the retina is from the lens, i e , the higher the degree of myopia, the more convergent they will be, and the nearer to the front of the eye will be the point where they cross This point is again the conjugate focus to the point on the retina, but in this case it is a real point It is also called the remote or far point of the eye

Where then is the far point of the emmetropic eye? We have seen that in each of the other conditions it is where the rays emitted from a point on the retina meet after emerging from the eye. In the emmetropic eye the emergent rays are parallel to each other. But parallel rays meet at infinity, therefore the far point of the emmetropic eye is at infinity.

It is obvious that, in hypermetropia, if we give the rays the requisite amount of convergence before they enter the eye they will be brought to a focus upon the retina. We can do this by placing a convex lens in front of the eye (Fig 35). This is what is done by means of spectacles. The refractive or convergent power of a convex lens is the reciprocal of its focal distance. Hence in hypermetropia of 1 D, a convex lens of 1 D or 1 metre focal distance placed in contact with the cornea will direct parallel rays towards a point 1 metre
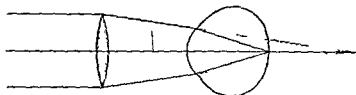
FIG 35—Hypermetropic eye. Parallel incident rays brought to a focus on the retina by means of a suitable convex lens.

behind the eye, i e, to the far point of the eye. Such a lens acting in combination with the refractive force of the eye would bring the rays to a focus on the retina. But lenses can only rarely be worn in contact with the cornea (v p 535). If the lens is placed 20 mm in front of the cornea its focal length will have to be 1,020 mm instead of 1,000 mm (*vide* p 34), but this small difference is negligible, and we are accustomed to measure errors of refraction by the strength of the lens which is required when it is placed in the ordinary position of a spectacle lens (Fig 35)

Similarly in myopia, if we give the rays the requisite amount of divergence before they enter the eye they will be brought to a focus upon the retina. We do this by placing a concave lens in front of the eye (Fig 36). Here we should want a – 1 D lens in contact with the cornea to correct a myopia of 1 D, i e, an eye whose far point is 1 metre in front of the eye. Since the glass has to be worn about 20 mm in front of the eye it will have to be rather stronger, i e, it will have to be of a focal distance of 980 mm, instead of 1,000 mm

There is an advantage in having the correcting glass in ametropia in the position of the anterior focus of the eye, because under these conditions the size of the retinal image is exactly the same as if the eye were emmetropic (Figs 37, 39) The anterior focus is about 13 mm in front of the eye, and this is so close that the lashes are apt to rub against the glasses, soiling them and causing discomfort Hence spectacles are usually placed slightly farther away   We have already discovered one effect of this, viz, that the convex glass in hypermetropia has to be rather weaker, and that the concave glass in myopia has to be slightly stronger   It also has an effect upon the size of the retinal image, making it larger in hypermetropia and smaller in myopia (Figs 38, 40)   The increase in size in hypermetropia is advantageous, but the diminution in myopia is a disadvantage, especially in very
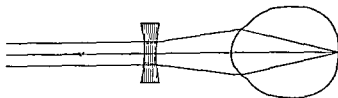
Fig 36 —Myopic eye   Parallel incident rays brought to a focus
on the retina by means of a suitable concave lens.

high degrees   Consequently in the latter the glasses ought to be made to fit as closely to the eyes as possible, the eyelashes being cut short if necessary

We have seen that in every case the far point and a point on the retina are conjugate foci   Hence an object situated at the far point of any eye will have a sharp image upon the retina (Fig 34)   This may be made clearer perhaps if we consider the myopic eye from another point of view   We have seen that the rays from a point on the retina meet in front of the eye at the far point   We may again use the principle of reversibility of rays   If there is a luminous point at the far point, the rays emitted from it which enter the eye will meet on the retina , in other words, the image of an object at the far point will be upon the retina

From these considerations we learn how it is that a patient with myopia cannot see clearly things which are a long distance away, whereas he can see things which are near   In common parlance, he is " short sighted " He can see things at a distance better if he screws up his eyes   This is because
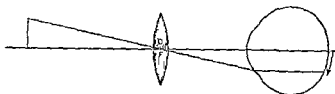
Fig 37.
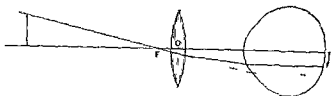
Fig 38.
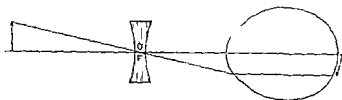
Fig 39.
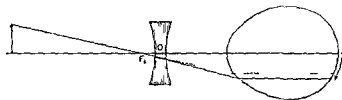
Fig 40

Figs 37–40 —Effect of correcting lenses upon the size of the retinal image   In Figs 37, 39, where the optical centre of the lens O, coincides with the anterior focal point of the eye F_1, the size of the retinal image is the same as in emmetropia   When the lens is closer to the eye than the anterior focal distance of the eye the size of the retinal image is diminished (convex lens Fig 38) or increased (concave lens, Fig 40)

he thus makes a narrow slit to look through, and this slit acts like the hole in the cardboard before a candle (vide p 23) The term myopia originated in this peculiarity (μύεω, to shut; ὤψ, the eye or countenance)

The patient with hypermetropia, on the other hand, can see neither distant nor near objects clearly with his eyes at rest, since the far point is virtual, and it is impossible to place an object at its situation We shall see later that he is better off than the myope by virtue of accommodation

We have already seen that the emmetrope sees only distant objects clearly with his eyes at rest, since the rays from such distant objects are nearly parallel For practical purposes
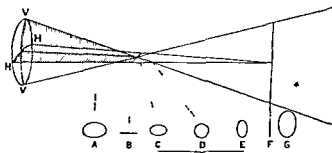
Fig 41 —Sturm s conoid V V, vertical meridian of refracting surface, more curved than H H the horizontal meridian. A B C, D E F, G, sections of conoid. From B to F is the focal interval of Sturm D shows the circle of least diffusion.

objects more than 6 metres (20 feet) away from the eye form clear images upon the retina

The condition of an eye, whether emmetropic, hypermetropic, or myopic, is called its refraction, or more accurately its static refraction, since the term applies to the eye at rest

We have hitherto considered only such errors of refraction as are due to axial shortening or lengthening of the eye (*axial ametropia*) It is not difficult to understand that ametropia might be due to other causes Thus, myopia might be due to the refractive power of the eye being too strong, in this case parallel rays would be brought to a focus in front of the retina even if this were in its normal position Increase or decrease in the refractive power of the eye might be due to two causes It might be due to alteration in the refractive

indices of the media, or to alteration in the curvatures of the refractive surfaces   ametropia due to these causes is called *index* or *curvature* ametropia respectively   Both are much less common than axial ametropia   Index ametropia is very rare, though we shall have a physiological example of it later (*vide* p 52)

Curvature ametropia has a special importance, not because it gives rise to simple hypermetropia or myopia, but because it is the cause of another very troublesome error of refraction, called *astigmatism*   In most eyes, even if they are ametropic, the areas of the refractive surfaces uncovered by the pupil and used in vision are very nearly spherical   Sometimes, however, they are not   In most of these cases it is the cornea which is at fault, and the error is generally of such a nature that this surface is flatter from side to side than it is from above downwards   Even in these cases the curvatures in the vertical and horizontal meridians are both spherical, but the radius of curvature of the horizontal meridian is longer than that of the vertical   Such a surface is said to have a *toric* curvature   Perhaps the pressure of the lids on the globe tends to squeeze it above and below

What will be the effect of such a toric cornea upon the refraction of the eye?   Clearly the more curved meridian will have more refractive or convergent power than the less curved   hence if parallel rays fall upon the surface the vertical rays will come to a focus sooner than the horizontal   The rays after refraction will be perfectly symmetrical when referred to the vertical and horizontal planes   They will have two foci   The whole bundle of rays is called Sturm's conoid, and the distance between the two foci is called the focal interval of Sturm   It is difficult to represent this conoid on a plane surface (Fig 41), but we can see what sections of the bundle or pencil of rays would look like at different distances from the refractive surface (Fig 41 A—G)

Fig 42

At A the section will be a horizontal oval or oblate ellipse, because the vertical rays are converging more rapidly than the horizontal   At B the vertical rays have come to a focus, while the horizontal are still converging   the section will be a horizontal straight line
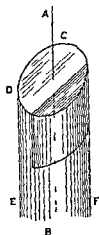
At C, D, and E the vertical rays are diverging and the horizontal are still converging   At one place in this focal interval there will be a spot (D) where the vertical rays have diverged from the axis exactly as much as the horizontal rays have converged towards it   Here the section is a circle, which is called the *circle of least diffusion*   At F the horizontal rays come to focus while the vertical are diverging   the section will be a vertical straight line   Beyond this point, as at G both sets of rays are diverging, and the section will always be a vertical oval or prolate ellipse

What will happen if the retina is situated at either of these points of section ?   In the first place it is obvious that the retinal image will always be blurred, and it is because the rays never come to a focus in a single point that the condition is called astigmatism (ἀ, privative, στίγμα, a point)   If the retina cuts the conoid at A, where none of the rays have come to a focus, every meridian will be in the same condition, though in different degree, as in the axial hypermetropic eye   this condition is therefore called *compound hypermetropic astigmatism*   If the retina is at B the vertical meridian will
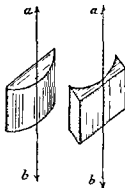
be in the condition of an emmetropic eye, while the horizontal will still be in the condition of a hypermetropic one   this condition is called *simple hypermetropic astigmatism*   At C, D, and E the vertical meridian will be in the condition of a myopic, and the horizontal still in that of a hypermetropic eye   this is called *mixed astigmatism*   At F the vertical meridian is still myopic, whilst the horizontal is in the same condition as in an emmetropic eye   this is *simple myopic astigmatism*   Beyond F, as at G, both

Fig 43

meridians are in the condition of an axial myope, the rays having crossed in the vitreous   this is *compound myopic astigmatism*   All these positions of the retina are met with in actual practice, though there is often a combination of axial and curvature defects

Distant vision is often found to be surprisingly good with relatively high degrees of mixed astigmatism, probably because the circle of least diffusion falls on or near the neuroepithelium of the retina

It will be readily seen that such a condition cannot be corrected by means of any spherical lens   We must obtain some means of affecting one set of rays more than the other   This means is found in cylindrical lenses

Suppose CDEF is a cylinder of glass (Fig 42)   AB is called the axis of
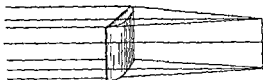
Fig 44 —Refraction of parallel rays through a plano convex cylinder

the cylinder   If a slice is cut off the cylinder by a plane parallel to the axis, it would form a cylindrical lens   Fig 43 gives representations of a convex and a concave cylinder   The direction ab is called the axis of the cylinder, since it is parallel to the axis of the original cylinder from which the slice may be supposed to have been taken   It is important here to warn the student not to confuse the axis of a spherical and the axis of a cylindrical lens, as they are totally different things   The axis of a cylinder has just been described the axis of a spherical lens is the line joining the centres of curvature of the two surfaces

How will a cylindrical lens affect parallel rays falling upon its surface ?   In the direction of its axis it is simply a plane lamina with parallel sides, so that it will have no effect upon the rays   In the direction at right angles to its axis it is
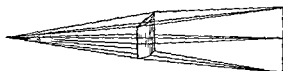
Fig 45 —Refraction of divergent rays from a point of light through a plano convex cylinder

spherical on one side and plane on the other   it will therefore act exactly like a plano convex or a plano concave lens, i e, it will make the rays either converge or diverge   If a convex cylinder is held between a point of light and a screen, a position can be found for the screen such that a sharp bright line is thrown upon it (Fig 45)   this is the focal line of the cylinder

It is to be noted that the line is in the direction of the axis of the cylinder   If another convex cylinder of the same strength were held with its axis at right angles to the first, it would obviously form a focal line perpendicular to the first focal line   If the two cylinders are put in contact with their axes at right angles, all the rays after refraction must pass

through both lines The only place where they can go through
both lines is where the lines intersect Hence we see that two
cylindrical lenses of equal strength, placed in contact with
their axes at right angles, act exactly like a convex spherical
lens of the same strength as either of the cylinders

When the cornea has its directions of greatest and least
curvature at right angles to one another, the condition is
called *regular astigmatism* In the commonest form, as we
have said, the vertical meridian is the more curved, the
horizontal the less this condition is generally called regular
astigmatism "according to the rule" Sometimes the reverse
is found this is said to be "against the rule" Not infre
quently the axes are oblique Often after ulceration, &c , the
surface of the cornea is irregular This causes the rays of light
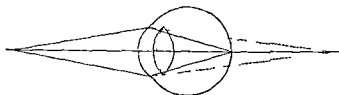
FIG 46 —Effect of accommodation. The dotted lines show the cur
vature of the anterior surface of the lens and the course of rays with
the eye at rest (static refraction). The solid lines show the curvature
of the anterior surface of the lens and the course of rays with active
accommodation (dynamic refraction).

to be refracted irregularly, so that there is no symmetry at all
about them and different groups form foci in various positions
This is called *irregular astigmatism* it cannot be corrected,
and can only occasionally be improved by glasses

Accommodation   We have to consider now how it is that
a person with normal sight can not only see distant objects,
but also near ones If an object is situated near the eye, *e g* ,
at ordinary reading distance—about 22 cm or 9 inches—the
divergence of the rays which it emits cannot be neglected
Since the converging power of the refractive media of the
emmetropic eye is only strong enough to make parallel rays
come to a focus on the retina, it is obvious that divergent rays
falling upon the cornea *will not nearly have come to a focus*
(Fig 46) They will indeed be made convergent, but only to
such a degree that they would meet somewhere behind the
retina Now if we can make the converging power of the eye
stronger, a point may be reached when it is just strong enough

to bring them to a focus on the retina This is what is done by accommodation and the manner in which the converging power of the eye is increased is by making the crystalline lens stronger

We have seen that the refractive power of a convex lens depends upon its refractive index and upon the curvature of its surfaces In accommodation it is the latter which under goes change The curvature of the surfaces of the lens at rest in the eye is approximately spherical and the radius of curva ture of the anterior surface is 10 mm while that of the posterior surface is 6 mm In accommodation the curvature of the posterior surface remains almost the same but the anterior surface changes so that in strong accommodation its radius of
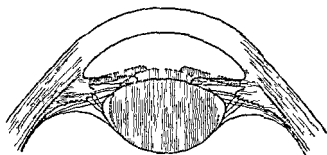
Fig 47 —Diagram of Helmholtz theory of accommodation

curvature becomes 6 mm The eye under these conditions which are called its dynamic refraction has a much increased converging effect upon the incident rays

The mechanism by which this change in the curvature of the lens is brought about is as follows (Fig 47) The lens sub stance is plastic so that it tends to conform accurately to the shape of its capsule As has been described (p 10) the capsule is anchored to the ciliary body by the suspensory ligament In the condition of rest the fibres of the suspensory ligament are stretched In the ciliary body is the ciliary muscle which takes its origin from its anterior attachment to the sclerotic at the angle of the anterior chamber When the muscle con tracts it pulls the posterior part of the ciliary body and the anterior part of the choroid forwards slightly The effect upon the suspensory ligament is to slacken it and with it the lens capsule The posterior surface of the lens is fixed by the sup port of the jelly like vitreous so that the slackening of

capsule makes itself most felt in the anterior part, which becomes bowed forwards. Since the anterior capsule is thicker behind the iris than in the pupillary area (Fig 48) there is a nipple like bulging of the lens through the pupil (Fincham)

The generally accepted theory here described is that of von Helmholtz. According to Tscherning the ciliary muscle tightens the suspensory ligament so that the peripheral parts of the anterior surface of the lens are flattened and the central or pupillary area is increased in curvature

Our control over the ciliary muscle, though involuntary, is very delicate, so that all distances up to quite close to the eye can be accurately focussed. The nearest point at which small
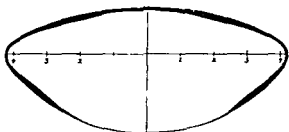
Fig 48 —Lens capsule constructed from post mortem specimens
Relative thickness magnified 100 times (Fincham)

objects can be clearly distinguished is called the *near point*, or *punctum proximum*. It is most accurately determined by gradually bringing a fine thread closer to the eye until it is found impossible to see it perfectly clearly. In practice it is sufficient to use very fine print and to determine the point at which it first becomes impossible to read it. The distance can be measured by a centimetre or inch tape held close beside the eye. For ordinary clinical purposes it is usually sufficient to judge the distance. At this point accommodation is exerted to its maximum, the lens capsule is as slack as it is possible to make it, and an object could only be seen clearly at a nearer point by placing a convex lens in front of the eye

It has been shown that the far point of the eye varies according to its static refraction, *i e*, according to whether it is emmetropic, hypermetropic, or myopic. The near point also varies with the static refraction, but it also varies with the age of the patient the reason being that the lens becomes less

plastic as age advances   We have stated that the lens is a
mass of epithelium of which the central part is the oldest (*vide*
p 9)   As the lens gets older the central cells become tougher
and more compressed, thus forming a relatively hard nucleus
The nucleus is less plastic than the younger cortex, and as age
advances more and more of the fibres become converted into
nucleus   Consequently the lens tends less and less to respond
to changes in tension of the capsule   Thus, a child of ten, the
earliest age at which it is possible to obtain satisfactory
measurements, is able to see a small object clearly when it is
only 7 cm , or less than 3 inches, from the eye   A person of
thirty years of age cannot see clearly at less than 14 cm , or
about 5½ inches, from the eye

Now, we have pointed out that the refractive power of a
lens in dioptres is the reciprocal of its focal distance measured
in metres (*vide* p 32)   The same method is applied to measure
the *static and dynamic refractive powers* of the eye   Thus,
the static refractive power of a myopic eye whose far point
is 1 metre in front of the eye is said to be 1 dioptre , this is
usually expressed by saying that the eye has 1 D of myopia
Similarly, if a hypermetropic eye has its far point half a metre
behind the eye it is said to have 2 D of hypermetropia   By
this method the emmetropic eye, which has its far point at
infinity, has no refractive power when it is at rest, since

$$\frac{1}{\infty} = 0$$

Applying the same method to the dynamic refractive power,
the child of ten, whose near point is 7 cm from his eye, has

a refractive power of $\frac{100}{7} = 14$ D , and a man of thirty, whose

near point is 14 cm from his eye, has a refractive power of

$\frac{100}{14} = 7$ D

By this means we can obtain a general rule for indicating
the amount or *amplitude of accommodation*, not only of emme
tropic but also of hypermetropic or myopic eyes   This is
given by the formula A = P — R which states that the ampli
tude of accommodation is equal to the refractive power of
the eye when fully accommodated (i e , the reciprocal of the
distance of the near point in metres) less the refractive power
of the eye at rest (i e , the reciprocal of the distance of the far
point in metres)

A few examples will make this clearer   Thus, the emmetropic child of ten has an amplitude of accommodation of $\frac{100}{7} - \frac{1}{\infty}$ = 14 − 0 = 14 D   What is the amplitude of accommodation of an emmetrope whose near point is 12 5 cm from his eye ?   Here A = $\frac{1000}{125} - \frac{1}{\infty}$ = 8 D   From statistics which have been collected we can deduce that this man was about twenty six years old (vide p 54)   Now let us take a case of myopia, e g , a myope of 2 D whose near point is 8 cm in front of his eye   His amplitude of accommodation will be A = $\frac{100}{8} - 2$ = 10 5 D   What is the amplitude of accommodation of a hypermetrope of 3 D whose near point is 12 5 cm from his eye ?   Here the far point is behind the eye and distances measured in this direction must have the opposite sign to those measured in front of the eye   Hence A = $\frac{1000}{125}$ − (−3) = 8 + 3 = 11 D

The numbers given by these calculations for the amplitude of accommodation give the strength of the convex lens which would have to be placed in contact with the cornea in order that the near point might be brought to the required distance without using the accommodation   Several interesting facts come to light from the calculations   Thus a hypermetrope of 3 D has to exert 11 D of accommodation in order that he may see clearly at 12 5 cm , while an emmetrope has to exert only 8 D of accommodation to bring about the same result   We see, then, that the hypermetrope has to exert an amount of accommodation equivalent to the amount of his hypermetropia in order to focus parallel rays upon his retina, i e , he has to use this amount of accommodation in order to see distant objects clearly   Again, in the case of the myope of 2 D, his far point is half a metre, or 50 cm , from his eye , he can see clearly at that distance without accommodating, but he has to exert 10 5 D of accommodation in order that he may see clearly at 8 cm from his eye   This patient, then, has to exert nearly as much accommodation to alter his points of clear vision from 50 cm to 8 cm , i e , through 42 cm , that a hypermetrope of 3 D has to employ in order to move his point of distinct vision from infinity up to 12 5 cm   We see, therefore that the *range of accommodation* i e , the distance between the

far point and the near point, is not always the same for a
given amplitude

The effect of age upon the static and dynamic refraction is
given in Fig 50, which is the result of a large number of
statistics and gives the average results From this table we
see that even the far point alters in advanced age After about
fifty the eye tends to become hypermetropic, so that at eighty
it has about 2 5 D of hypermetropia This has nothing to do
with accommodation, and hence nothing to do with loss of
plasticity in the lens It is, however, due to changes going on
in the lens, viz , an alteration in its refractive index so that it
has a weaker converging power

*The refractive indices of the successive layers of the lens increase
from the periphery towards the nucleus* The effect is twofold

Fig 49

it tends to correct aberration by increasing the con-
vergence of the central rays, and the total refractive
index of the whole lens is increased, being greater
than the refractive index of the nucleus For the
lens may be looked upon as a central bi convex lens
encapsuled in two menisci (Fig 49) The menisci act
as concave lenses because the curvature of the nucleus
is greater than that of the periphery of the lens
Hence they tend to counteract the effect of the central
lens, but not so much as if their refractive index was the same In
old age the index of the peripheral

layers usually increases, so that the
total refractive index of the lens
becomes less and the eye becomes
hypermetropic (cf p 311)

Examination with the slit lamp
(*vide* p 97) reveals three chief
surfaces of specular reflection
corresponding to the anterior
surface of the lens the surface of
the "adult nucleus," and the
surface of the "fœtal nucleus"
(Fig 50) separated by zones of
discontinuity The fœtal nucleus
corresponds to the lens at
birth Its centre, the "central
interval" is most homogeneous,

Fig 50

and therefore appears darkest (*vide* Fig 75, p 98) The adult
nucleus corresponds to the size of the lens in early adult life It
is separated from the lens capsule by the cortex, consisting of
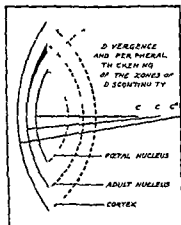
lens fibres laid down subsequently (*vide* p 9) Note that the radii of curvature of the successive bands diminish from without inwards so that they act as negative menisci

If we turn our attention to the curve of the near point we see that the amplitude of accommodation gradually diminishes throughout life Now, we are accustomed to hold books for reading or work for sewing &c , at about 10 inches or 22 cm
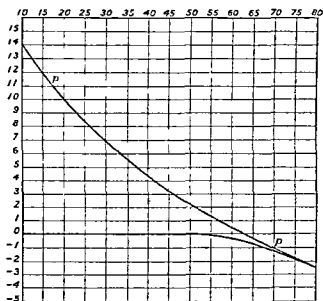
Fig 51 —Chart of static and maximum dynamic refraction at various ages (Donders) Abscissæ ages   ordinate accommodation in dioptres

from the eyes In order to be able to see clearly at 25 cm from the eye we have to exert $\frac{100}{25} = 4$ D of accommodation. If we look at the table we shall see that an emmetrope has only 4 D of accommodation left at about forty-one years of age He will still be able to see clearly at 25 cm but not closer If he is about forty six he will have only 3 D of accommodation left He will not now be able to see clearly at 25 cm , but he will have to hold his book farther off, viz at $\frac{100}{3} = 33$ cm If he is still older he will have to hold the book yet farther off and he will probably have to use very

large print or he will not see clearly at all This is the condition which is called *presbyopia* (πρέσβυς, old)

It will be seen that a patient never requires more than + 4 D to correct his presbyopia only, since that is the amount of accommodation required to place the far point of the resting emmetropic eye at reading distance A convenient rule to remember is that a presbyope may require + 1 D for every five years after forty , i e , at forty five, + 1 D, at fifty, + 2 D, at fifty five, + 3 D, at sixty and later, + 4 D The rule errs in giving too liberal a correction , a smaller correction is often more comfortable, and owing to considerable individual variation each case must be treated on its merits

It is a common error among students to think that presbyopia is a condition which commences at about forty five years of age in emmetropes, and earlier in hypermetropes Of course this is not so the condition which has been increasing throughout life first becomes troublesome when the near point of the eye has receded so far that it is beyond comfortable reading distance

There are two other phenomena which occur with accommodation, one affecting the iris, the other the direction of the eyes In order that we may see a near object we must look at it , hence in order that we may see it at the same time with both eyes they must each turn inwards or converge The amount of convergence, like the amount of accommodation, depends upon the distance of the object It is therefore easy to understand that there is a close relationship between accommodation and convergence We shall have more to say upon this subject when we consider the various forms of squint

When we accommodate for a near object the pupil becomes smaller, or contracts Experiment has shown that this movement of the iris is associated with the accompanying act of convergence rather than with accommodation *per se* It is probably of the nature of an associated movement, or, as I have termed it, synkinesis (συν, with, κίνησις movement)

Contraction of the pupil during accommodation is not for the purpose of diminishing aberration, since this is already diminished by the act of accommodation It has the effect of compensating for the relative increase of light entering the eye from near objects, but is greater than is necessary to produce this result

It is not uncommon for the refraction of the two eyes to be

different   this condition is called anisometropia (ă, privative, ἴσος, equal, μετρον, measure)   It might be anticipated that this could be corrected to some degree or entirely by unequal accommodation in the two eyes   Thus, if one were emmetropic and the other hypermetropic, both eyes would be able to distinguish distant objects clearly if the hypermetropic one alone accommodated the requisite amount to correct its hypermetropia   It has been conclusively proved, however, that this does not occur   When these cases are not corrected by the proper glasses clear vision is wholly uniocular

Although astigmatism is chiefly due to faulty curvature of the cornea, in some cases there is also lenticular astigmatism   This is not generally due to unequal curvature of the surfaces but to slight tilting of the lens, so that the incident rays fall upon it obliquely   If we look through a tilted glass lens at printed matter we shall see that the letters become distorted and elongated in one direction ,   this is a form of astigmatism   The astigmatism of the crystalline lens is generally of such a nature that it tends to counteract the corneal astigmatism, though sometimes it adds to the effect   As in anisometropia, it might be thought that astigmatism could be corrected by accommodation   If, for instance, the ciliary muscle acted only at the sides and not at all above or below, the anterior surface of the lens would become more curved in the horizontal than in the vertical meridian   This would counteract the effect of the ordinary form of corneal astigmatism   It has been proved, however, that this also does not occur   When the ciliary muscle acts, it acts equally all round the circle , and when one ciliary muscle acts, the one in the opposite eye acts simultaneously and equally under ordinary conditions

THE PUPILS

The iris acts like the diaphragm of any ordinary optical system, such as a photographic camera or a microscope   In discussing the effects of spherical mirrors in reflecting, and of spherical surfaces in refracting the rays of light, we said that in each case they were all brought to a focus in a single point   This is really only an approximation, which is sufficiently accurate for rays close to the axis   In a convex spherical lens, for instance, parallel rays near the axis meet at the principal focus (vide p 29)   The rays farther away from the axis, how ever, are refracted too much, so that they cut the axis nearer the lens than the principal focus (Fig 52)   This causes a

blurring of the edges of the image, which is said to be due to *spherical aberration* The diaphragm cuts off these peripheral rays, and thus prevents the blurring In the eye the surfaces are not even spherical near the periphery, and are often not so in the centre, so that much more aberration is liable to occur This reduces the effects of the evil to a minimum

There is also another form of aberration due to the imperfect refraction at spherical surfaces White light is made up of all the colours of the spectrum The component rays are refracted differently, the violet most, the red least Hence there is a tendency for the white light to be split up into its components, in which case the image will have a coloured edge This phenomenon is called *chromatic aberration*

When light enters the eye and falls upon the retina the pupil
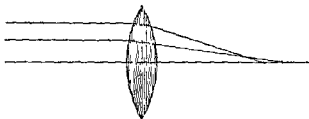
Fig 52 —Spherical aberration.

contracts We have already seen that the pupils also contract when the optic axes converge in accommodation On the other hand, they dilate if the skin of any part of the body is pinched or any sensory nerve is stimulated to the extent of causing pain These responses to stimuli of various kinds are very rapid and delicate, and are easily observed When they are altered by disease the changes which occur afford very valuable information as to the condition of the nerve tracts involved The tracts are rather complicated, but it is essential that they should be understood

Under normal conditions, with equal illumination—a point too frequently neglected—the pupils are equal on the two sides It is rare to meet with unequal pupils in a normal person, such cases do apparently occur, but every possible pathological cause must be eliminated before we admit that the condition is an idiosyncrasy

On the other hand, the size of the pupils varies much in different people under the same conditions of illumination, &c In old people it is smaller than in the young, sometimes to
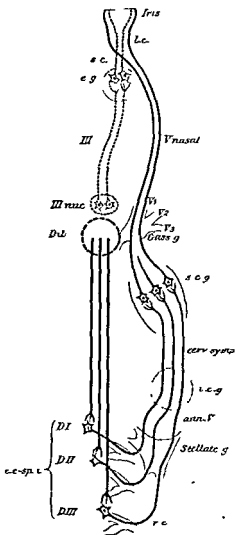
Fig 53.—Diagram of the efferent pupillary paths. Dotted lines, pupillo-constrictor: *III nuc*, nucleus of third nerve; *c g*, ciliary ganglion; *s c*, short ciliary nerves. Solid lines, pupillo-dilatator: *Dil*, hypothetical dilatator centre in the medulla; *c.c-sp.i*, Budge's centrum cilio-spinale inferius; *D I*, *D II*, *D III*, first, second, and third dorsal nerves (see text); *r c*, ramus communicans; *Stellate g*, stellate ganglion; *ann. V*, annulus of Vieussens; *i c g*, inferior cervical ganglion; *cerv. symp*, cervical sympathetic; *s c g*, superior cervical ganglion; *Gass g*, Gasserian ganglion; *V1, V2, V3*, first, second, and third divisions of the fifth nerve; *V nasal*, nasal branch of the ophthalmic (first) division of the fifth nerve; *l c*, long ciliary nerves.

so great an extent that the pupils are almost "pin point" They are often smaller in hypermetropes, and larger in myopes, than in emmetropes, they are said to be smaller in blue eyes than in brown   The causes of these differences are conjectural, and need not detain us   The two facts of prime importance have been mentioned, viz , that there are two reflexes, that to light and that to sensory stimulation, which act in opposite directions   The normal size of the pupil may be looked upon as essentially the resultant of these two forces

The motor innervation of the pupil is as follows (Fig 53)   The sphincter pupillæ is innervated by the third cranial nerve   The pupil constrictor fibres start in the anterior part of the third nucleus in the floor of the aqueduct of Sylvius   They pass out of the midbrain and run in the main trunk of the third nerve as far as the orbit.   Here the fibres pass into the branch which supplies the inferior oblique muscle, leaving it by the short root of the ciliary ganglion   From the ciliary ganglion they pass by the short ciliary nerves to the eye, piercing the sclerotic around the optic nerve, being here in company with the short ciliary arteries (vide p 11)   The nerve fibres pass forwards in the choroid and ciliary body to the iris

Fig 54 —Diagram of the afferent and efferent pupillary paths for light stimuli. Afferent paths from left sides of retinæ thick solid lines , afferent paths from right sides of retinæ, thick dotted lines , efferent paths of left eye, thin solid lines   efferent paths of right eye thin dotted lines. Ir , iris R, retina II optic nerve o tr , optic tract , Coll Supr , colliculus superior or anterior corpus quadrigeminum , IIIrd nuc , nucleus of third nerve , e g b , external geniculate body , c g , ciliary ganglion , s c n , short ciliary nerves

The dilatator pupillæ is supplied by the cervical sympathetic nerve   The dilatator tract probably commences in the midbrain not far from the constrictor tract   It passes downwards through the medulla oblongata into the lateral columns of the cord   The fibres leave the cord by the ventral roots of the first three dorsal and probably the last two cervical nerves, enter the rami communicantes, and run to the first thoracic or stellate ganglion   From here they pass by the anterior limb of the annulus of Vieussens into the cervical sympathetic   In this nerve they run up the neck to the superior cervical ganglion, whence they pass with the carotid plexus into the skull   They run over the anterior part of the Gasserian ganglion and pass into the first or ophthalmic division of the fifth nerve, following the small branch, which they leave finally to enter the long ciliary nerves, thus avoiding the ciliary ganglion   The long ciliary nerves enter the eye on each side of the optic nerve, accompanying the long ciliary arteries   Like them, they run forwards between the choroid and sclerotic, enter the ciliary body and thus reach the iris

These complicated paths will be seen at a glance in the accompanying diagrams (Figs 53, 54)

We have now to consider the nervous mechanism of the reflexes   The light reflex is carried out entirely through the constrictor centre, so we may put the dilatator tract aside for the moment   The afferent fibres are contained in the optic nerve arising from all parts of the retina (Fig 51)   It is unknown whether they belong to the large or the small fibres of the optic nerve   It is certain that they undergo partial decussation in the chiasma, like the visual fibres, and that they enter the optic tracts   It is also certain that, unlike the visual fibres, they do not enter the lateral geniculate body, but leave the tract to pass by an unknown path to the third nucleus

The constrictor centre possesses " tone," i e , it is perpetually sending out impulses which keep the pupil slightly contracted   If light falls upon the retina of one eye its pupil contracts—*the direct reaction to light*, but the pupil of the opposite eye also contracts simultaneously—*the consensual reaction to light*   This consensual reaction should always be tested, since it gives useful information which cannot be obtained from the direct reaction   Thus, if there is a block on one optic nerve so that there is no direct reaction to light, but the consensual reaction from light thrown upon the other eye is unimpaired, we know that the block, whatever it may be,

does not affect the efferent constrictor tract, i e, the trunk of the third nerve the branch to the inferior oblique, and the short ciliary nerves are intact   The consensual reaction is probably carried out by means of fibres which unite the two constrictor centres in the third nucleus

That the afferent pupil constrictor fibres undergo partial decussation in the optic chiasma is proved by Wernicke's *hemianopic pupil reaction* This reaction is pathognomonic of disease of one optic tract It will be seen from Fig 54 that such a lesion will cut off the afferent impulses from corresponding halves of each retina, i e, from the temporal half of one and the nasal half of the other If light is thrown upon these parts of the retinæ the pupils do not contract, but if it is thrown on the other halves of the retinæ the pupils respond

The sensory reflex is more complicated than the light reflex, for both the dilatator and the constrictor centres play a part in its production under normal conditions It has been shown that sensory stimulation causes first a rapid dilatation of the pupil due to augmentation of the dilatator tone through the cervical sympathetic, and then a second dilatation, rapid in onset but slow in disappearance, due to inhibition of the constrictor tone There are other reflexes and synkineses, e g, emotional, which need not detain us

Minute examination of the pupil when the intensity of the light entering the eye is altered, shows that the pupil contracts and then oscillates rapidly, finally settling down into a condition of contraction which is slightly less than the summit of the first wave In its sudden response, the pupil as it were oversteps the mark, oversteps it again in the opposite direction, and so on Two different types of exaggeration of this oscillation are met with under abnormal conditions One is the condition in which the oscillations are very large and easily seen, and which are to a large extent independent of the light falling upon the eye This is called *hippus*, its origin is obscure, but it undoubtedly depends upon the rhythmic activity of the nervous centres, and is not a peripheral phenomenon More important is the lack of sustained contraction under the continued influence of light Here the pupil contracts sluggishly when the intensity of the light is increased, but while the light is still kept constant it slowly dilates, often with superposed sluggish oscillations This is a pathological phenomenon dependent upon diminished conductivity in the afferent path of the light reflex, i e, usually in the optic nerve (see Retrobulbar Neuritis)

Drugs are so frequently employed in ophthalmic practice for the purpose of dilating or constricting the pupils or paralysing the accommodation that it is important to know exactly how they act Pupil dilating drugs are called mydriatics, pupil constricting, miotics, drugs which paralyse the ciliary muscle, cycloplegics All drugs which dilate the pupil also paralyse the accommodation in greater or less degree, many attempts have been made to discover a drug which will effect the former purpose without the latter but without success. Similarly, all miotics stimulate the ciliary muscle to contract, so that the eye assumes a condition of partial or complete accommodation

Most of these drugs do not apparently act directly on the muscles or on the nerve endings Constriction of the pupil by the third nerve is due to the liberation of acetylcholine (Englehardt) Atropine destroys or prevents the formation of this substance hence it can only be counteracted by substances which act directly on the muscle, e g, histamine Eserine acts by preventing the normal rapid destruction of acetylcholine, hence the extreme irritability of the sphincter and ciliary muscle, and of the eye in bright light Hence, eserine cannot counteract atropine mydriasis whereas atropine easily counteracts eserine miosis

The strongest mydriatic which we possess is *atropine*, it paralyses the sphincter iridis and ciliary muscle completely, and is said also to stimulate the dilatator iridis It has so potent an action that it abolishes the tone of the ciliary muscle Thus an emmetropic eye placed fully under the influence of atropine becomes hypermetropic to the extent of about 1 D, this must be taken into account in correcting errors of refraction Atropine solution (e g, 1 per cent) instilled into the conjunctival sac is absorbed through the cornea into the anterior chamber, where it acts locally upon the intrinsic muscles It takes a considerable time to cause complete paralysis, hence it is usual to order it for use at home three times a day for at least three days The effects do not pass off for about ten days One drop of 0 5 per cent atropine sulphate solution causes weak dilatation of the pupil in thirty to forty minutes and complete paralysis of accommodation in about two hours, the effects do not pass off entirely till from three to seven days Duboisine, hyoscine or scopolamine, and daturine act similarly to atropine

Homatropine acts more quickly than atropine, and the effects pass off more quickly Its full effect is obtained by an only

tion (in 0l nicm, 1 per cent) in three quarters of an hour,
ecially if combined with cocaine (2 per cent), which acts
fly by increasing the permeability of the cornea   The
ets pass off completely in forty eight hours, or much more
kly if a drop of eserine (1 per cent) is instilled   The mix-
of homatropine and cocaine, which is commonly employed
estimating refraction, does not paralyse the intrinsic
cles so fully as atropine, the tone of the ciliary muscle not
g abolished so thoroughly   Homatropine probably acts
n the iris through the sphincter only

ocaine, besides its anæsthetic effect through the endings of
fifth nerve in the cornea, iris, &c , also stimulates the sym-
hetic nerve endings in the dilatator iridis   It does not para-
the sphincter, so that the dilatation of the pupil is only
lerate, and the pupil continues to react to light even after
longed application   Cocaine is a useful drug in confirming
diagnosis of paralysis of the sympathetic nerve   if this
ve is paralysed cocaine fails to dilate the pupil   The effect
t due to degeneration of the nerve endings, as I have found
t cocaine fails to act very soon after section of the
pathetic in the neck in animals

serine, or physostigmine, the most powerful miotic we
sess, acts by stimulating the third nerve endings in the
ncter and in the ciliary muscle   It is therefore an anta-
ist of atropine, but it is unable to overcome the dilatation
duced by 1 per cent atropine   On the other hand, eserine
hily overcomes the dilatation produced by homatropine and
aine   These facts are of very great importance and must be
efully borne in mind   Comparably with cocaine eserine fails to
duce constriction of the pupil after section of the third nerve
Eserine, unlike the common mydriatics, causes some smart
and injection of the ciliary vessels when instilled into the
junctival sac   What is more unpleasant is the "dragging"
sation in the eye which patients complain of when it is
ing   It may be so irritating as to cause vomiting, but this
y occurs in very sensitive persons or when the drug is pushed
ing to these symptoms it should not be instilled more fre-
ntly nor in stronger doses than requisite to ensure the
ired result   A 0 5 per cent solution or one considerably
ker is often adequate

Eserine begins to contract the pupil and cause spasm of
ommodation in about five minutes , its maximum effect
reached in twenty to forty five minutes   The effect on
ommodation lasts only an hour or two, that on the pupil
o to three days

Pilocarpine causes miosis by directly stimulating the para sympathetic apparatus, thus differing in its action from eserine The action is less prolonged and may be followed by a fatigue reaction—slight mydriasis

In irritative miosis, due to stimulation of the third nerve, light, accommodation, and eserine will cause greater constriction, atropine dilatation   In paralytic miosis, due to paralysis of the sympathetic, light, accommodation, and eserine will cause constriction, atropine little or no dilatation

In spastic mydriasis light, accommodation and eserine will cause constriction   In paralytic mydriasis there is no reaction to light or accommodation, and eserine acts very feebly

Adrenaline causes dilatation of the pupil in cases of acute pancreatitis (Loewi)   four drops of 1 in 1000 solution should be instilled into one conjunctival sac, and the instillation repeated in five minutes   The dilatation is manifest after half an hour, the pupil being often oval (Garrod)

Histamine ("amino glaucosan") produces maximum miosis by acting directly upon the muscle fibres

VISUAL PERCEPTIONS

When light falls upon the retina it acts as a stimulus to a sensory nerve ending   As contact of the skin with a foreign substance causes the sensation of touch, so stimulation of the retina causes visual perceptions   The changes which go on as the result of a suitable stimulus in an ordinary tactile end organ, the physiological impulses in the afferent sensory nerves, and the psychological interpretation of these impulses in the brain which we call tactile sensation, are all relatively simple. In the visual nervous mechanism they are much more complex and highly differentiated

We may first very briefly consider the changes which occur in the end organ itself   Light falling upon the retina causes at least four effects   (1) The pigment in the hexagonal cells of the retinal epithelium migrates from the bodies of the cells in o the processes which lie between the rods and cones   (2) The cones become shorter   Both these effects are slow, both give more response to the violet end of the spectrum than to the red end, both are consensual as well as direct—light on one retina causes the effect on both, though the other be kept in darkness   (3) The visual purple, a substance which is found only

in the rods, is bleached, so that a sort of photograph or opto
gram of the luminous object is formed   (4) Changes of elec
trical potential are set up in the retina

We are more concerned, however, with the sensations which
result from stimulation of the retina with light   These are
of three kinds which are called the Light Sense, the Colour
Sense, and the Sense of Form   Each of these may become
disordered, so we must examine what they really mean

The *Light Sense* is the faculty which permits us to perceive
light not only as such, but in its gradations of intensity   By
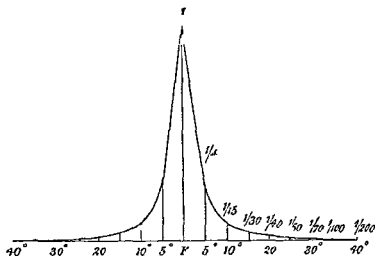
Fig 5a —Acuity of form sense in different parts of the retina   (Dor)
F fovea centralis   Abscissæ degrees towards the periphery of the
retina ordinates relative acuity that at the fovea being unity

utilising shadows cast by the retinal blood vessels upon the
rods and cones it can be proved that the neuro epithelium is
the actual sentient layer of the retina (Purkinje's experiment)
It is in this layer that the clear images of objects in the outer
world are focussed   The rays stimulate the rods and cones and
give us the sensation of light   Hence rays falling upon the
optic disc give rise to no visual sensation and this is therefore
called the *blind spot* (Mariotte)

If the light which is falling upon the retina is gradually
reduced in intensity there comes a point when it is no longer
perceived   this is called the *light minimum*   It varies very
greatly according to the amount of light which has been falling
upon the retina before the observation is made   We are all

aware that if we go from bright sunshine into a dimly lit room we cannot perceive the objects in the room until some time has elapsed   the eyes have to become "adapted" to the amount of illumination   Hence observations on the light minimum are only comparable one with the other when the eyes are in the same condition of dark adaptation   Since this involves keeping light from the eye for at least twenty to thirty minutes the investigation is tedious, and perhaps this is the chief reason why it is much neglected clinically   The light minimum for the fovea is considerably higher than for para central and peripheral parts of the retina and retinal adaptation affects the macula relatively little

Having ascertained the light minimum, if the light is gradu ally increased in intensity there are points at which we can clearly distinguish a difference in the amount of illumination We can do this best if we have two illuminated areas of equal size to compare, as is done in special instruments for the pur pose, called photometers   We can then find out how much brighter one area must be in order that we may distinguish a difference in illumination   This is called the *light difference* It is found to vary with the amount of illumination—the greater the amount of illumination the greater will have to be the difference in order that we may be conscious of any difference at all   Indeed, light difference tends to follow a well known law which is approximately valid for all sensory impressions (Weber's Law)

Neither of these functions of the light sense is much used in ophthalmology   There is no doubt that the light minimum is increased in diseases which impair the percipient elements, viz , the rods and cones (*see* Retinitis pigmentosa)   It is said that disease of the conducting elements, the nerve fibres, causes increase in the light difference

The rods are much more sensitive to low illumination than the cones, so that in the dusk we see with our rods (*scotopic vision*)   Nocturnal animals like the bat, have few or no cones

The *Form Sense*, which is next in importance, is the faculty which enables us to perceive the shape of objects in the outer world   Here the cones play the predominant part, and where they are most massed together and most highly differentiated, viz , at the macula, the form sense is most acute   It falls off very rapidly towards the periphery, as is shown in Fig 55, and it is noticeable that the curve agrees fairly well with the diminution in the number of cones   We are accu-

tomed to speak of acuity in distinguishing the shapes of objects as *acuity of vision*, and we mean by that the greatest acuity which it is possible to obtain   The acuity of vision, therefore, applies to central vision, or the vision of objects whose images are formed at the fovea and its immediate neighbourhood, the macula lutea

The form sense is not a purely retinal function, but in the perception of composite forms—such as letters—is largely psychological   A punctate source of light does not form a punctate retinal image, but a circle of diffusion   The size and definition of this depends upon the resolving power of the eye, regarded as an optical instrument and varies with the wave length of the light, pupil aperture, etc   The purely physiological elements which enter into the complex form sense are (1) the light sense, (2) the sense of position, (3) the sense of discrimination   The sense of position depends upon the light sense and upon the conditions of contrast between the object and its background   A physiological process, called spatial induction, causes a lowering of sensibility of the area surrounding a stimulated area, so that the demarcation between the two areas is increased   The sense of position is measured by the *minimum visibile*   The sense of discrimination is the power to distinguish two visible objects as separate, and is measured by the *minimum separabile*   The finest sense of discrimination of any sensory organ is the visual capacity to distinguish an irregularity in the line of demarcation between two contours, which is of the order of a visual angle of 5 seconds of arc—much less than the so called minimum visual angle (*v infra*)   It is the basis of the accuracy of physical measurements with the vernier   Form sense is measured by the *minimum legibile* or *cognoscibile*

In determining the acuity of vision, we utilise the visual angle (*vide* p 37)   We naturally choose as our basis the *minimum visual angle*, i e , the angle which two luminous points must subtend at the nodal point of the eye in order that they may be perceived as separate and distinct   Now, in order that we may get separate impressions from two points close together on the retina it is necessary that two cones shall be stimulated, and that there shall be a cone between these two which is not stimulated   If we know the diameter of a cone we can calculate the minimum angle which must be subtended at the nodal point in order that these requirements may be fulfilled   This angle, as we have already seen, is equal to the angle subtended on the other side of the nodal point by the two luminous points   As a matter of fact these co￫

agree fairly well with the results of observations It might be thought that the observation was a very easy one, but there are several complications It is found that there is a certain amount of spread of the stimulus from one cone to surrounding ones due to the size of the pupil spherical and chromatic aberration and irregular astigmatism of the refractive media especially the lens, it is somewhat diminished by diffraction at the edge of the pupil This causes bright objects on a dark background to appear a little larger than they really are the phenomenon is called irradiation. It is not altogether a disadvantage for it helps us very much in seeing actual points of intense light, like the stars millions of miles away In clinical work it would be a disadvantage to have an unduly high standard of visual acuity, because nearly everybody would be abnormal according to the standard It is found that a minimum visual angle of 1 minute (1') or one sixtieth of a degree gives a very good average, and it is upon this basis that test types are constructed (*vide* p 131)

The *Colour Sense* is that faculty whereby we are enabled to distinguish different colours and different colour tones The exact investigation of the colour sense is one of great complexity, for the different colours of the spectrum differ in luminosity, so that this disturbing factor has to be added to those dependent upon the physiological condition of the retina *e g*, its state of adaptation, and so on

Appreciation of colours occurs only with lights of moderate or high intensity and some degree of light adaptation of the retina (*photopic vision*) If a spectrum of low intensity is viewed with the dark adapted eye it appears as a grey band differing in brightness in different parts (*scotopic vision*) The brightest part is at about 530 $\mu\mu$ corresponding to the green of the photopic spectrum The brightest part of the photopic spectrum is at about 580 $\mu\mu$ near the sodium line in the yellow Scotopic vision is essentially a function of the rods, colour vision of the cones (duplicity theory)

If three colours sufficiently far apart in the spectrum are chosen all the other colours though not in the same degree of saturation can be formed by their combination in suitable proportions, and white light can also be formed in the same manner Hence normal colour vision is called trichromatic. There are reasons for choosing red green and blue for these 'primary' colours Now, we know that physiological impulses are in some sense a reflex or image of the physical

stimuli which give rise to them, e g , sound waves cause physiological impulses, which are perceived as sound, and so on   If, therefore, we imagine three slightly different kinds of impulse set up by the stimulation of the retina by red, green and blue light respectively, their combinations in suitable proportions would enable us to perceive the whole gamut of the spectrum, including white light   This is the basis of the Young Helmholtz theory of colour vision   According to Hering's theory, chemical changes in three different types of "visual substance" situated in the retina cause the sensations of colour (including white and black)   The three substances are white black, red green, and blue yellow   If anabolic or building up changes (assimilation) are set up in these substances, the sensations of white, red and blue are caused respectively   If katabolic or breaking down changes (dissimilation) are set up, black, green and yellow result

Perhaps no subject affords a better field for conjectures than the theory of colour vision   It is sufficient here for us to emphasise the importance of the three primary colours, upon which stress is laid by the Young Helmholtz theory, and the intimate relations which exist between red and green, blue and yellow, and white and black, which are the foundation of the Hering theory   It is necessary to realise so much because the colour sense is defective in a fairly large proportion of people This congenital abnormality is called *colour blindness* (q v) In it the importance of the three primary colours and the intimate relation of the pairs of colours are forcibly brought out

The three types of visual perception are not confined to the minute area of central or macular vision   All are present in greater or less degree in more peripheral parts of the retina   In disease the earliest and most delicate traces of failing function are often to be found in the peripheral parts, central vision remaining perfectly normal   Hence the great importance of knowing the normal limits of the light perceptive and the colour perceptive areas of the retina

The *field of vision* is the projection of these percipient areas of the retina on the outer world   When we stand upon the seashore and look at, or "fix," a ship on the horizon it forms a retinal image at the fovea   We are accustomed, then, to consider that any object in the outer world which forms the image at the fovea is situated somewhere upon the *line of vision*, i e , the line passing through the fovea and the nodal point of the eye   The foveal image is "projected" outwards along this line   Whilst still fixing the ship we are conscious of

seeing, less clearly, innumerable objects for miles around
From our knowledge of the refractive mechanism of the eye
we know that these objects must form their retinal images
upon peripheral parts of the retina   Regarded from the side
of the eye the image upon any point of the peripheral part of
the retina is " projected " outwards along the line joining the
point with the nodal point   The field of vision, then is the
projection outwards of all the points upon the retina which can
give rise to visual perceptions   We will postpone the considera-
tion of its properties to a later stage (*vide* p 138)

CHAPTER V

The Neurology of Vision

In the preceding chapter we have considered the process of vision up to the point at which the retinal receptive elements the rods and cones have become stimulated   As with other
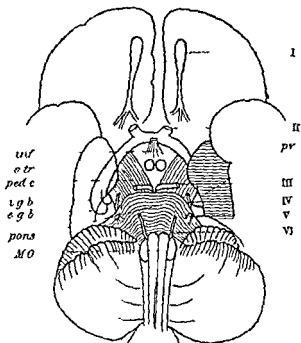
Fig 56 — Diagram of the base of the brain showing superficial origin of the I II III IV V and VI cranial nerves *i f* infundibulum *o tr* optic tract *ped c* cerebral peduncle *i g b* internal geniculate body *e g b* external geniculate body *pv* pulvinar of optic thalamus *M O* medulla oblongata

sensory nerves stimulation of the end organ causes the development of nervous impulses which travel up the afferent tracts of the central nervous system to the brain The comparison of the afferent tracts of common sensation with those of vision throws so much light upon the latter that it is worthy of a moment's consideration
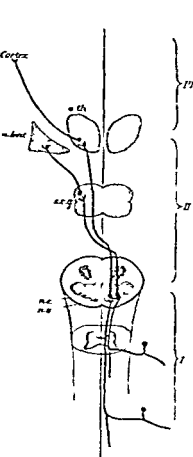
FIG. 57
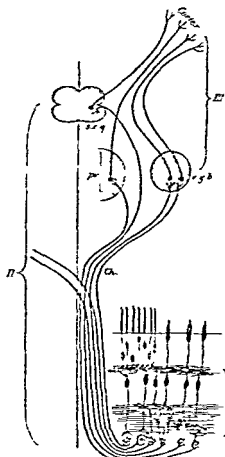
FIG. 58

FIGS. 57 and 58.—Fig. 57 represents a diagram of the neurones of the most direct path of common sensation. Fig. 58 represents the neurones of the afferent visual path. I, II, III neurones of the first, second, and third orders respectively. *n.c.*, nucleus cuneatus; *n.g.*, nucleus gracilis; *s.c.q.*, superior corpus quadrigeminum; *n.lent.*, nucleus lentiformis; *o.th.*, optic thalamus. 1 in Fig. 58 rod and cone bipolars in the retina. *Ch.*, chiasma; *e.g.b.*, external geniculate body; *pv.*, pulvinar of optic thalamus.

The sensory impulse of common sensation *e.g.*, in the leg is carried by a nerve fibre along the sensory nerve and the dorsal spinal root to the cord. It travels up in the posterior column of the cord to the nucleus gracilis or the nucleus cuneatus as the case may be (Fig. 57). The whole of this course is along

the processes of a single cell or neurone, which has been called the neurone of the first order. The impulse is taken up in the nucleus gracilis or cuneatus by a second cell, and is carried along the nucleo thalamic tract or mesial fillet to the opposite optic thalamus; other fibres, especially those derived from the nucleus cuneatus, pass to the superior colliculus or corpus quadrigeminum. The cells in the nuclei gracilis and cuneatus
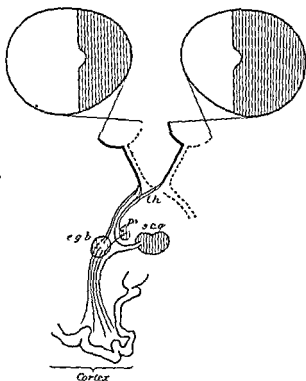
Fig 59—Diagram of the afferent visual paths from the retinæ, with the corresponding fields of vision (After von Monakow) *Ch*, chiasma; *pv*, pulvinar of optic thalamus; *e g b*, external geniculate body; *s c q*, superior corpus quadrigeminum.

are the neurones of the second order. A third cell, the neurone of the third order, situated in the thalamus or colliculus, carries on the impulse to the cortex cerebri. Here the nervous impulse is transformed into a psychic impulse, a change which is not and probably never can be understood.

Let us compare with this the visual afferent tracts (Fig. 58). The end organ is the neural epithelium of rods and cones. The first true conducting nerve cell or neurone of the first order is

the bipolar cell of the inner nuclear layer with its axon in the inner reticular layer This microscopic cell corresponds morphologically with a dorsal root ganglion cell and its long processes stretching in some cases from the tip of the toe to the top of the spinal cord The neurones of the second order are the ganglion cells in the retina whose processes pass up the nerve fibre layer and along the optic nerve to one of three terminations most (80 per cent) end in the lateral or external
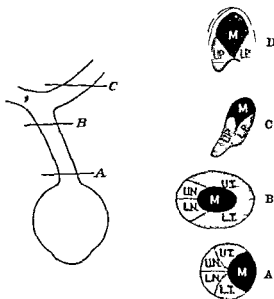
Fig 60 —D stribution of fibres of the Optic Nerve M macular U T upper temporal L T lower temporal U N upper nasal L N lower nasal U P upper peripheral L P lower peripheral A B in optic nerve C in tract D in external geniculate body The right-hand portion of the figure is reproduced from Eugene Wolff s Anatomy of Eye and Orb t   Lewis London (After Brouwer & Zeeman)

geniculate body, others pass to the optic thalamus and a few go to the superior colliculus At these three sites a new cell the neurone of the third order takes up the transmission of the impulse travelling by way of the optic radiations of Gratiolet to the cortex of the occipital lobe which is the so-called *visual centre*

We see then the morphological identity of the two systems in spite of the great anatomical differences which specialisation has brought about We may emphasise again the fact that the peripheral optic nerve proper is a bipolar cell in the inner nuclear and inner reticular layers of the retina while the

so called optic nerve is a part of the central nervous system homologous with the mesial fillet in the medulla and pons

We must now investigate more minutely the individual parts of the visual system The results which are about to be described are derived from three sources—embryology, experiments upon animals, and clinical observation as controlled by post-mortem findings

Let us first trace the fibres from the various parts of the retina (Fig 59) In general it may be said that the fibres from peripheral parts enter the middle of the nerve, while the fibres from parts near the nerve enter the peripheral parts of the nerve they probably maintain this relative position as far back as the chiasma There is, however, one disturbing factor, viz, the fibres from the macular region This part is specially well supplied The fibres pass into the outer part of the nerve, where they are spread over an area which is triangular in section, with the apex towards the centre of the nerve (Fig 60) These *papillo macular fibres* soon become more centrally situated, so that in the posterior part of the nerve they are all in the centre Tracing them still farther backwards some decussate in the chiasma, while others enter the optic tract of the same side They pass to the posterior two thirds of the lateral geniculate bodies (Le Gros Clark) The axons of their corresponding neurones of the third order are also widely distributed in the optic radiations and end in the lips of the calcarine fissure of the occipital lobe, probably along its whole length We see then that each macular region is represented in each occipital lobe, so that no lesion confined to one occipital lobe will abolish central vision in either retina

According to Gordon Holmes and Lister, from observations on patients with gunshot wounds of the occipital lobes, the maculæ are represented at the most posterior part of the visual cortex, probably on the margins and on the lateral surfaces of the occipital poles, each macula is represented only in the opposite occipital lobe (Figs 63 64)

The fibres from peripheral regions of the retina, on the other hand, form two distinct groups, corresponding with the temporal and nasal halves of the retina The limitation is very exact, as if a vertical line divided the retina into two halves at the level of the fovea, since the foveal fibres have a different distribution the line makes a little curve round it so as to avoid

it (Fig 59) The fibres from the temporal half of the retina
enter the chiasma but do not decussate , they pass into the
optic tract of the same side Thence they run to the lateral
geniculate body, and a few to the thalamus and superior colli
culus The fibres from the nasal half of the retina enter the
chiasma, decussate and pass into the optic tract of the opposite
side having a similar distribution on the other side The direct
and crossed fibres pass to alternating laminæ in the lateral
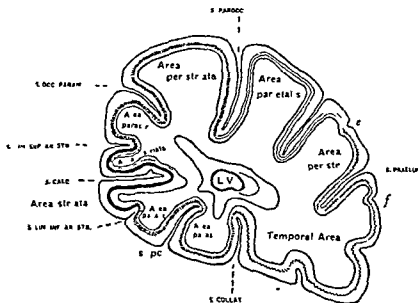
Fig 61 —A diagram to represent the distribution of the different cor
tical areas in a coronal section through the left hemisphere one centi
metre behind the fossa parieto occipital s LV posterior cornu of
lateral ventricle s calc posterior calcarine sulcus s lim.sup ar str
sulcus cunei (sulcus limitans superior areæ striatæ) s lim inf ar str ,
sulcus lingualis (sulcus limitans inferior areæ striatæ) Note how the
stripe of Gennari (the thick black line) ends abruptly at the bottom
of the sulcus cunei and the sulcus lingualis (After Elliot Smith)

geniculate body (Minkowski, Le Gros Clark) The corre
sponding neurones of the third order pass by the optic radia
tions to the corresponding occipital lobes We see, therefore,
that a lesion of one occipital lobe or optic tract will cause blind
ness of the temporal half of the retina on the same side and of
the nasal half of the retina on the opposite side Projecting
this outwards, such a lesion will cause loss of vision in the
opposite half of the binocular field of vision, a condition which

is known as *hemianopia* (hemiopia, hemianopsia) We may
recall the fact that the afferent pupil-constrictor fibres have a
similar semi decussation in the chiasma

The visual fibres in the optic radiations maintain a posterior
position in common with the sensory fibres from the rest of the
body, being thus situated behind the motor fibres in the
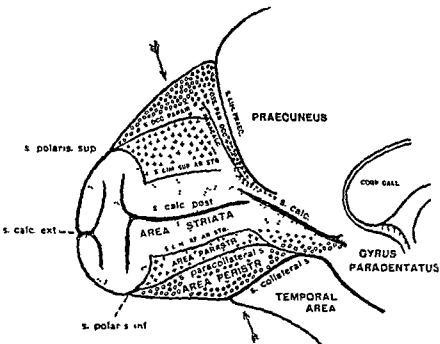
Fig 62—A diagram to illustrate the distribution of the cortical areas
on the mesial surface of the occipital region of the left hemisphere
The two arrows indicate the plane of the section shown in Fig 61
The area striata is represented by dots   the area parastriata by
crosses   the area peristriata by circles   (After Elliot Smith)
Compare the above with Gordon Holmes's diagrams (Figs 63 64)
arrived at on clinical grounds

internal capsule   They are close to the posterior cornu of the
lateral ventricle, so that they are liable to pressure here when
the ventricle is distended

The occipital cortex in and about the calcarine fissure differs
from the cortex elsewhere in the possession of a white line, the
line of Gennari, interpolated in the grey matter   This area,
which is the primary visual or visuo sensory area (Figs 61-64),
is the cortical projection of the corresponding halves of both
retinæ   In this projection the part above the calcarine fissure

represents the upper corresponding quadrants the part below the lower corresponding quadrants of both retinæ

It may be mentioned that there are efferent fibres in the optic nerves   They are axons of cells in the lateral geni
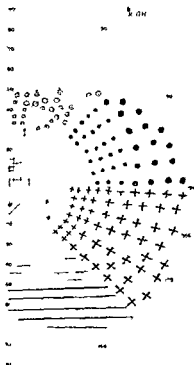
FIG 63   FIG 64

FIG 63—A diagram of the probable representation of the different portions of the visual fields in the calcarine cortex   Fig 63 is a drawing of the mesial surface of the left occipital lobe with the lips of the calcarine fissure separated so that its walls and floor are visible   The markings of the various portions of the visual cortex which is thus exposed correspond with those shown on the chart (Fig 64) of the right half of the field of vision   (Gordon Holmes)

culate body Their function is unknown but they are probably concerned in the movements of the pigment epithelium and of the cones , possibly also in the chemical changes in the visual purple

SECTION II

THE EXAMINATION OF THE EYE

CHAPTER VI

External Examination

OPHTHALMIC patients may be roughly divided into two groups those who present manifest objective signs of disease and those who presenting no outward and visible signs have abnormal subjective symptoms The division is convenient both in theory and in practice The second group, in all but functional ' cases have latent objective signs which it is our duty to discover In the first group the manifest signs may mask even more serious conditions which it is our duty to bring to light Not infrequently we are confronted with obscure cases which demand the most careful systematic examination in order that nothing may be overlooked Though it is not always possible, or even necessary, to go through the lengthy routine of an exhaustive systematic examination yet the details of such a routine must be firmly engrafted in our minds, ready for instant application, if we wish to avoid mistakes in diagnosis

We shall first describe the methods of examination of the parts which can be observed with the unaided eye, though we shall often ensure accuracy by artificial assistance Next, we shall describe the methods which must be employed to examine the deeper parts of the eye Finally, we shall map out a routine of systematic examination

In the patients who belong to our first group we shall at once be confronted with visible signs of disease We shall not consider in this place gross signs such as marked protrusion or proptosis great deviations of the optic axes from the normal parallelism, and so on These will be more conveniently investigated in their special relations We shall confine ourselves to conditions affecting the globe itself

The Conjunctiva In the normal position of the lids only that part of the bulbar conjunctiva which is exposed in the palpebral aperture, together with parts of the intermarginal strip along the edges of the lids, is visible In order thoroughly to investigate the whole conjunctival sac it is necessary to expose the palpebral conjunctiva and the fornices

The lower fornix is easily exposed by drawing down the lower lid while the patient looks towards the ceiling

The upper palpebral conjunctiva is exposed by everting the upper lid

Eversion of the upper lid requires some practice   (1) The best, and often the easiest, method is as follows   Stand facing the patient   Place the right index finger horizontally along the patient's left upper lid while he looks towards his feet Draw the skin of the lid outwards   this causes the inner part of the edge of the lid to come forwards, while at the same time the pressure of the finger affords a fixed point around which the lid can revolve in a vertical direction   Insinuate the right thumb under the projecting edge of the lid, and roll the lid upwards towards the index finger   The right lid is everted in the same manner, using the left hand

This method is very easy when the eyes are prominent, and it causes a minimum of discomfort to the patient   When the eyes are deeply set in the orbit, as is often the case in old people whose orbital fat has become to a great extent absorbed, more pressure is needed and a little pain is caused   In such cases the following method may be adopted , the tyro will generally find it easier

(2) Place a probe or thin pencil horizontally along the skin of the upper lid at the level of the upper border of the tarsus the patient looking towards his feet   Seize the eyelashes between the left index and thumb, and draw the lid away from the globe, using the probe as a fixed point   Rotate the lid in a vertical direction round the probe, which is then withdrawn

In many cases we wish to evert the upper lid when standing behind the patient, who may be lying on a couch   In this case the following is the best method

(3) Place the left index finger vertically upon the lid while the patient is looking towards his feet   Seize the lashes with the right index and thumb, and rotate the lid around the tip of the left index

In babies a special arrangement of the patient facilitates thorough examination of the conjunctival sac and eye

(4) The surgeon sits facing a nurse, who holds the child on her lap   The baby's head is placed between the surgeon's knees, its body is on the nurse's lap   She holds the child's hands against its body, thus keeping them out of the way, and at the same time steadying the child   If, as is often the case, there is blepharospasm, eversion of the lids is extremely easy, indeed, it becomes troublesome when we wish to examine the cornea   Here the spasm of the orbicularis fixes the lids against the globe, and the slightest attempt to draw the lids apart causes both to become everted   When this does not occur, method (3) must be adopted

Having everted the upper lid we can examine the palpebral conjunctiva, but we are still unable to see the upper fornix   This can usually be effected in adults by the following manœuvre   (1) With the lid still everted by the first method it is fixed in that position by the left thumb placed upon its margin at about the middle   The right thumb or finger is placed in the middle of the lower lid   Firm, steady pressure is then made through the lower lid upon the globe in a direction straight backwards, as if to push the globe into the orbit   In the meantime firm pressure is also exerted backwards upon the upper lid with the left thumb   The fornix will generally start forwards suddenly, but only if the patient keeps looking well down towards his feet all the time

This method, though unpleasant, is not painful   The only other method of exploring the upper fornix is more effectual, but also painful   The eye should therefore be well cocained

(2) The upper lid is everted in the usual manner   A retractor is then inserted under the everted lid into the fornix   The margin of the lid being fixed as in (1) the lid is everted a second time, so that the fornix is fully exposed   Sometimes it is necessary to grasp the everted lid with forceps and thus evert it a second time

By these manœuvres the conjunctival sac can be thoroughly *explored*   *Special attention must be paid to the favourite* sites for foreign bodies and manifestations of disease, e g, foreign bodies often lodge on the palpebral conjunctiva about 2 mm from the margin at about the middle of the lid, trachoma follicles are most marked in the upper fornix , scarring from old trachoma is most marked in the palpebral conjunctiva, &c. Adhesions between palpebral and ocular conjunctiva and obliteration of either fornix cannot fail to be noticed   Inflammatory conditions can be thoroughly examined , accurate

diagnosis often depends upon minute investigation Patches
of granulation tissue which bleed easily may mark the site of
embedded foreign bodies, or, if on the palpebral conjunctiva,
the site of a chalazion

The ocular conjunctiva can be almost completely examined
without everting the lids if the eye is moved up and down
while the lids are kept apart The redness which is observed
in irritative and inflammatory conditions varies in its distri
bution and nature according to the cause Here we must
remember the groups of vessels with which we have to deal
(*vide* p 11 , Plate II) Three groups may be distinguished,
though most of them are too small to be recognised in health

FIG 65 —Conjunctiva con
gestion—engorgement of
the posterior conjunctival
arteries and veins (After
Guthrie)
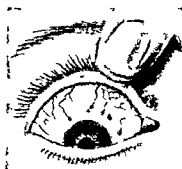
FIG 66 —Congestion of the per
forating branches of the anterior
ciliary arteries (After Dalrym
ple) The dusky spots at the
seats of perforation are often seen
in dark complexioned persons

(1) the proper vessels of the conjunctiva or posterior con
junctival vessels , (2) the anterior conjunctival vessels, which
supply the area adjacent to the limbus or corneal margin and
send minute loops into the edge of the cornea itself (Fig 65),
(3) the anterior ciliary vessels, lying in the subconjunctival
or episcleral tissue (Fig 66) In the last group the perforating
branches of the arteries are seen in health as several compara
tively large tortuous vessels which suddenly cease about 4 or
5 mm from the corneal margin They have very numerous
small episcleral branches which are invisible in health, but
when dilated form a pink zone of fine, straight, very
closely set vessels around the cornea The corresponding
perforating veins are very small, but more numerous than

the arteries, their episcleral branches form a closely meshed network

Congestion of the individual groups of vessels affords important evidence as to the seat of the mischief The conjunctival vessels can be distinguished from the anterior ciliary by the following points (1) they are a brighter brick red, the ciliary vessels being seen through the conjunctiva, which imparts a purple tinge, (2) if the conjunctiva is moved to and fro over the sclerotic by the finger placed on the lower lid, the conjunctival vessels also move while the ciliary remain stationary, (3) the individual vessels and the network they form can be seen in the conjunctival system whereas the ciliary form for the most part a diffuse reddish violet blush in which the separate vessels are indistinguishable, (4) if the blood is

FIG 67 —Ciliary congestion—en
gorgement of episcleral twigs of
the anterior ciliary arteries
(After Dalrymple)
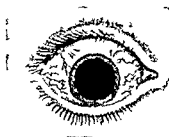
FIG 68 —Congestion of the an
terior ciliary veins episcleral
venous plexus (After Dal
rymple)

pressed out of the vessels the ciliary fill up at once on removing the pressure, since they anastomose very freely while the conjunctival fill slowly

In general, congestion of the conjunctival vessels, leaving a relatively white zone around the cornea, accompanied by mucous or muco purulent secretion, is indicative of conjunctivitis If there is much irritation and so-called photophobia with some blepharospasm and very watery—lacrymal—secretion we suspect the presence of a foreign body on the cornea or under the lid so that it rubs against the cornea the condition may be due to misplaced lashes (trichiasis) Phlyctenular ophthalmia may produce a similar picture In such a case there is also usually congestion of the anterior conjunctival vessels Careful examination shows that the vessels in the circumcorneal zone are bright red, and that the corneal

loops are also dilated and visible Any irritation of the cornea—ulcers, abrasions, &c —causes this conjunctival congestion of the circumcorneal zone and corneal vessels Though conjunctival they do not move with the membrane A definite leash of dilated vessels confined to the conjunctiva or encroaching upon the cornea is usually indicative of a foreign body on the cornea or phlyctenular disease

Pink circumcorneal congestion is also met with in inflammation of the iris Here the anterior ciliary vessels are also involved

Circumcorneal congestion of a peculiar lilac tint, more deeply seated and often patchy, is associated with cyclitis and deep scleritis This is the condition which is known as ciliary congestion *par excellence*

Dusky congestion at the limbus, composed of a fine reticulum —the episcleral venous plexus—often points to glaucoma, but may accompany other diseases, especially in old people

These conditions run into one another very frequently, so that they then cease to have special diagnostic importance

Lacrymal Apparatus   Conjunctival congestion of one eye only, or signs of irritation such as watering should lead us to suspect the efficiency of the lacrymal apparatus Simple epiphora or flow of tears on to the cheek may be due to blocking of one or both puncta or to their malposition, or to blockage elsewhere in the canaliculi or nasal duct Displacement of the lower punctum may be easily overlooked The puncta are not visible normally without slightly everting the lids Displacement is often very slight, due to slackness of the lid causing a little rolling out or ectropion, especially in old people In spasm of the orbicularis the lid may be rolled in too much (entropion), this may also cause epiphora Sometimes with more conjunctival inflammation, but often without, there is distension and chronic inflammation of the lacrymal sac In all such cases we carefully observe the exact position of the puncta, whether they are in apposition to the bulbar conjunctiva as they should be, and also whether there is any regurgitation from the lacrymal sac when it is pressed upon The lacrymal sac is situated in the lacrymal fossa between the inner canthus and the nose the fundus of the sac extends slightly above the level of the inner palpebral ligament which is on a line with the canthus Pressure inwards and backwards in this position will press upon the sac If there is any obstruction to the flow of the contents into the nose by the nasal duct, as is usually the case when the sac is inflamed,

the contents will generally regurgitate into the conjunctival sac by way of the canaliculi, and will be seen pouring from the puncta We note whether the contents are tears, mucus, or muco pus

Without describing special methods of ascertaining if the lacrymal passages are patent (Chap XXXII) a simple test may be mentioned A drop of fluorescein solution is placed in the conjunctival sac and the patient is told to blow his nose If the passages are free, the handkerchief will be stained with the solution

The Sclerotic Inspection of the sclerotic around the cornea may reveal raised nodules of episcleritis with their localised areas of vascular congestion (*vide* p 250) Deep scleritis may be shown by dusky ciliary congestion and opacification of the deeper layers of the cornea at the periphery (sclerosing keratitis, *vide* p 252)

Definite blue coloration of the circumcorneal sclerotic, except in young children is pathological It is most frequently due to ciliary staphyloma, a giving way of the sclera owing to inherent weakness (injury, scleritis &c) or to increased intra ocular pressure (glaucoma) Discoloration may be due to pigmentation Slight duskiness around the spots where the anterior ciliary vessels perforate is not uncommon in people with dark complexions Otherwise pigmentation in this neighbourhood, either in the conjunctiva or sclerotic should be regarded with suspicion as indicative of melanotic sarcoma Definite nodules of deeply pigmented tissue in the situation of the perforating vessels are very significant of sarcoma of the ciliary body

If there is bulging of the sclerotic an attempt should be made to transilluminate it in the dark room If it is a true ectasia (staphyloma) light will pass through into the eye The light should be concentrated upon the spot by a strong lens (*vide* p 87)

The abrupt or very gradual curvature of the sclerotic as it passes back from the cornea may indicate high hypermetropia or myopia respectively

The Cornea A little experience will enable us to recognise at a glance if the cornea is smaller than usual A small cornea with a shallow anterior chamber is very suggestive of glaucoma

The cornea should be bright and transparent We first examine its surface Any loss of substance, such as an abrasion may easily be overlooked without special care

The condition of irritation and lacrymation will often put us on the track, but these features may be so slight as to pass unnoticed   The following methods should be adopted

(1) Place the patient facing the window   Stand in front and direct the patient to follow the index finger, which is held horizontal and moved slowly up and down   The finger is then
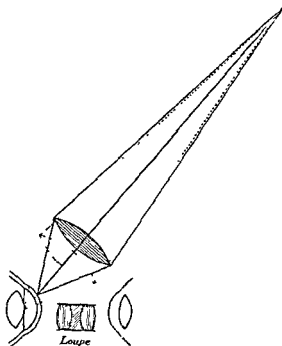
Fig 69 —Focal or oblique illumination   The diagram shows how the focus of the light may be altered by slightly shifting the position of the concentrating lens

held vertical and moved from side to side   While these manœuvres are being carried out the image of the window, or corneal reflex as it is called, is carefully watched   If the surface of the cornea is normal there will be no distortion of the reflex as it passes over it   If there is an abrasion the image will be distorted here, and will be less clearly defined   This method should always be resorted to first, as it is good practice in observation and needs no artificial aid, which may not be available in some circumstances

(2) If the first method gives uncertain results or fails, instil a drop of fluorescein solution (2 per cent) This is best done by telling the patient to look towards his feet, the conjunctiva above the cornea is then lightly touched with the tip of a glass rod which has been dipped in the solution   A pad of cotton wool is immediately placed upon the closed lids so as to mop up the excess and the tears which tend to flow over the face   If this detail is not attended to the face becomes stained unnecessarily   It is a good plan to wash out the excess of fluorescein with a drop of pantocain solution but it is not essential   Any spot on the surface of the cornea which is denuded of epithelium will appear green

A bundle of dilated conjunctival vessels near the limbus will often point to the site of a foreign body upon the cornea

Opacities of the cornea may be so faint that they require very minute investigation, and the same is true of the details —depth, &c —of gross opacities   We can study them best by focal or oblique illumination

Focal or oblique illumination is carried out as follows (Fig 69) the patient is placed, preferably in the dark room, with a light about two feet in front but slightly to one side   The light is concentrated upon the cornea by a strong convex lens   The rays of light are brought to a focus by the lens   The cornea or other superficial structures can thus be examined under the intense light of the converging rays   The position of the minute image of the light formed by the lens can be moved over the surface of the cornea by slight lateral movements of the lens without altering the position of the light   Similarly the light may be focussed upon the iris or crystalline lens by moving the lens slightly nearer to the eye   A small electric torch is a convenient source of illumination

Having thus brilliantly illuminated the part of the cornea which we wish to investigate, we may magnify the spot by looking through a very strong convex lens or corneal loupe held in the other hand   The management of the two lenses requires a little practice, but is easily mastered   A few words of explanation about the corneal loupe will help us to employ it to best advantage

When we magnify a small object with a strong convex lens we place it within the focal distance of the lens and view it through the lens   We know that under these conditions the lens forms an enlarged image upon the same side as the object, but farther away (vide p 30, Fig 21)   In order that we may see the image to best advantage we must see as much of it as

possible, and we must see it under the largest possible visual angle The first requisite demands that the observer's eye shall be as close to the lens as possible The second requisite depends upon the relative distances of the object and the eye from the lens, in practice these are found by slight movements of the lens

In employing focal illumination, then, first focus the light upon the required spot Then place the corneal loupe near the spot and look through it Slowly advance the loupe towards the cornea until the spot comes into focus Then get one's eye as close to the loupe as possible

By moving the light and the loupe slowly over the whole surface of the cornea we can thoroughly explore it By advancing the convex lens we can illuminate successively the back of the cornea, the iris and anterior part of the lens, and finally the deeper parts of the lens By simultaneously advancing the position of the loupe towards the cornea we can successively bring these structures into accurate focus and examine them under considerable magnification We cannot get beyond the back of the lens with a high power loupe, as it works at too short a focal distance Moreover, in order to examine the deeper parts of the lens, we must have the light almost in front of the patient, otherwise they will not be illuminated

With a binocular loupe a stereoscopic effect is obtained, and the depth of opacities can be determined with great accuracy, but the degree of magnification is less Special methods of examination with the binocular loupe, Gullstrand's slit lamp, contact illumination, &c, are useful in difficult cases (*vide* p 97)

Focal illumination without the assistance of a loupe or a dark room is often of great advantage through the good illumination which it affords One soon gets into the habit of concentrating the light from the window upon the eye with the convex lens with a view to improving the optical conditions

The cornea is often affected secondarily to the conjunctiva, as in phlyctenular ophthalmia In such conditions the eye is most irritable and resistant to examination in bright light The slightest attempt to separate the lids is accompanied by violent blepharospasm, especially in children Yet it is in such cases that it is of the greatest importance to know and watch the condition of the cornea For aught we know it may be ulcerated, and may even be upon the point of becom-

ing perforated   Any roughness or even an amount of pressure which is quite justifiable in other cases, may suffice to cause the perforation which it should be our chief effort to avoid   In such a case the lids must be separated by retractors   We may use simple bent wire retractors (Fig 70) or Desmarres' retractors (Fig 71)   In babies the position recommended in method (4), p 81, is employed   older children are placed upon a couch   The retractors are inserted gently into the palpebral aperture, first the upper then the lower, the curved ends being insinuated between the lids and the globe   Traction is then made upon the retractors not only in opposite directions up and down, but also away from the globe, so that the lids are lifted off the globe at the same time that they are separated   In these cases the globe tends to roll forcibly upwards when light falls upon it, which makes it very difficult to see the cornea even with the use of retractors   The difficulty may be overcome by pressing the end of the lower retractor well into the lower fornix, which drags the eye downwards by pulling on the ocular conjunctiva

Fig 70 — Bent wire lid retractor

Fig 71 — Desmarres lid retractor

When we have satisfied ourselves that there is little or no fear of perforation we may dispense with retractors   It has been pointed out that in children any attempt to separate the lids when there is much blepharospasm is usually followed by eversion of both lids the cornea still remaining hidden   The way to overcome this difficulty is to place the two thumbs close to the edges of the lids and to press gently but firmly upon the globe as the lids are drawn apart   In this manner they are separated without becoming everted, but we must be extremely careful not to exert undue pressure and not to touch the cornea with the thumb nails

In many diseases new vessels are formed in the cornea   An

exact knowledge of their position, whether superficial or deep,
and of their distribution, whether localised, general, peri
pheral, above, and so on, will often settle a disputed point in
diagnosis

Superficial vessels (Fig 72) in the cornea are distinguished
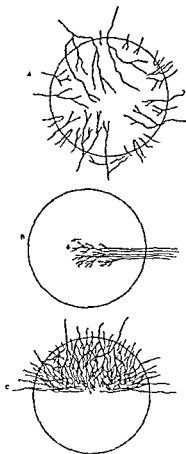
Fig 7. —Diagrams of superficial corneal vessels   A general vascu
larisation   B a single leash of vessels as in fascicular ulcer (vide
J 22") C localised vascularisation as in trachomatous pannus
(vide p 177)

from deep (Fig 73) by the following features   (1) superficial
vessels can be traced over the limbus into the conjunctiva
while deep ones seem to come to an abrupt end at the limbus ,
(2) superficial vessels are bright red and well defined, while
deep ones are ill defined, greyish red or cause only a diffuse

red blush, (3) superficial vessels branch in an arborescent fashion, dichotomously, while deep ones run more or less parallel to each other in a general radial direction, and branch at very acute angles, like a besom, (4) superficial vessels may raise the epithelium over them so that the surface of the cornea is uneven, while with deep ones the cornea, though hazy, is smooth. The peculiar course of deep vessels is probably determined by the lamellar structure of the substantia propria.

The sensibility of the cornea may be tested by touching it in various spots with a wisp of cotton wool twisted to a fine point and comparing the effect with the opposite side. Normally there is a brisk reflex closure of the lids. The sensibility is often diminished in corneal affections, but the change is of some diagnostic significance in certain cases, e g, herpes (vide p 229)

The Anterior Chamber The anterior chamber is shallow in extreme youth and in old age, at other periods of life it is about 2 5 mm deep normally. It must be remembered that we estimate the depth of the anterior chamber by the position of the iris, and that we view the iris through the cornea, which is a strongly refracting convex surface. The effect of this is to magnify the iris and pupil, and to make it appear farther forwards than it really is. The same

Fig 73 — Diagram of deep corneal vessels, as in interstitial keratitis (vide p 234)

applies to anything in the anterior chamber, e g, the point of a knife in operations.

Good binocular vision enables us to estimate the depth of the anterior chamber when we are looking at it from in front. The observation should be confirmed by taking a profile view.

The anterior chamber is abnormally shallow in glaucoma. It is often abnormally deep in irido-cyclitis. It is frequently unequal in depth in different parts. For example, it may be deeper at the periphery than in the centre in irido-cyclitis, on the other hand, when the iris is bowed forwards (iris bombé) it is funnel shaped the centre being deep, the periphery very shallow. It may be deeper on one side than on the other owing to tilting (subluxation) of the lens.

After considering the depth, attention must be paid to the contents. In some wounds and ulcers of the cornea, and rarely without them, there is pus in the anterior chamber. It

forms a layer at the bottom, the surface of the pus being level (hypopyon) A similar layer of blood may occur after contusions or spontaneously (hyphæma) The aqueous may be hazy, a condition not always easy to distinguish from haziness of the cornea Such cases lead us to examine very carefully the back of the cornea with the loupe under focal illumination to see if there are any precipitates ('keratitis punctata") upon it, or we may see flocculent specks in the aqueous All these conditions are of great diagnostic and prognostic importance

The Iris We pay attention first to the *colour* of the iris and the clearness of its pattern The two irides or parts of the same iris may be of different colour, both conditions being known as heterochromia iridis A grey iris, with ill-defined pattern, suggests atrophy from cyclitis, glaucoma, &c Dark brown spots in the iris, not raised above the surface, are common. Care must be taken to distinguish them from small nodules of the same colour or white (sarcoma, tubercle gumma) "Muddiness of the iris" is the expression used for indistinctness of the pattern, caused by inflammatory exudates A muddy iris with small irregular pupil and sluggish reaction to light is indicative of iritis

The position of the iris must be noted especially the plane in which it lies (*vide* pp 262, 271, 284) Special attention should be paid to any adhesions (synechiæ), anterior—to the cornea or posterior—to the lens capsule *Tremulousness* of the iris (iridodoness) is seen when the eyes are moved rapidly if the iris is not properly supported by the lens, e g , in absence, shrinkage, or dislocation of the lens slackness of the suspensory ligament &c It is best seen in a dark room with oblique illumination

The Pupils A point which should be examined at an early stage in every routine examination of the eyes is the condition of the pupils This is the more important since the routine examination frequently demands the use of a mydriatic, and if the pupils have not previously been noted it may be necessary to require the attendance of the patient on another occasion when the effect of the mydriatic has passed off

The examination of the pupils requires careful attention *to* details if trustworthy results are to be obtained It is best carried out as follows

Place the patient facing the light which should not be too bright , see that the two pupils are equally illuminated Note the size, shape and contour of each pupil Cover both eyes

with the palms of the hands, preferably without touching the face Tell the patient to look straight at you Remove one hand and watch the pupil Replace this hand and remove the other, watching the other pupil Note down and compare the results (*direct reaction to light*) Remove one hand so that this eye is exposed to light (it should be shaded from intense light) Watch this pupil as the hand is removed from the other eye Repeat the process whilst watching the other pupil (*consensual reaction to light*)

Now tell the patient to look quite across the room, as far off as possible Suddenly hold up the index finger vertically, at about six inches from the patient's nose, and tell the patient to look at it Watch the pupils while he accommodates for the finger (*reaction to accommodation*)

When the reaction to light is feeble and the pupils are already small it is difficult to be certain of the results in bright diffuse daylight, the corneal reflexes adding to the difficulty In such cases the patient should be taken into the dark room and the light concentrated upon one pupil by focal illumination By a slight lateral movement of the convex lens (*vide* p 87) the focus of light can be moved on or off the pupil, the pupillary movements being watched the while If there is no movement under these conditions we may conclude that the reaction to light is absent

It is better not to use the ophthalmoscope mirror in this procedure, as the patient is very likely to look at it, and a reaction to accommodation may be mistaken for one to light Note very carefully if the constriction of the pupil to light is well maintained (*vide* p 395)

The same method will elicit the *hemanopic pupil reaction* (Wernicke) in the rare cases (lesion of one optic tract) in which it is present To test for it, the light is placed in front but rather to one side of the patient The light is focussed with the lens upon the opposite side of the retina, and the pupil watched The light is then moved to the other side and is now focussed on the other side of the retina The best source of illumination for this purpose is the diffuse light from a large window (Fisher) If the reaction is present the pupil will react briskly when one half of the retina is illuminated, but very slightly or not at all when the other half is illuminated It usually reacts slightly even in the latter case, owing to the impossibility of preventing diffusion of light on to the sensitive half of the retina, and for this reason the test is rarely unequivocal

When the pupils are small to start with ("spinal miosis"), do not react to light, but react to accommodation, the condition is known as the *Argyll Robertson pupil* (*vide* p 593) It occurs especially in para syphilitic disease, most commonly and in its most characteristic form in tabes, and frequently in general paralysis of the insane, but it is also found in other syphilitic diseases of the central nervous system.

If the above directions are carried out we shall have reliable information as to the shape and relative size of the pupils and their reactions A few of the commoner conditions may be enumerated here

Very large pupils will suggest that a mydriatic has been used It is not uncommon for it to have been used inadvertently We not infrequently see a patient with the right pupil widely dilated complaining of dimness of vision. Inquiry will often elicit the fact that he has been using a liniment for rheumatism The explanation is that the liniment contained belladonna, and that after using it with his right hand he rubbed his right eye with the soiled fingers Often patients use ointment or drops prescribed for other patients We must always be on our guard against such traps These pupils are usually quite immobile and the patient complains of dimness of vision, especially in near work.

The pupil is also large and immobile in complete atrophy of the optic nerve, this may be due to absolute glaucoma In acute glaucoma it is usually large, immobile, and oval, with the long axis vertical, the condition is generally unilateral If only one eye is blind from disease of the optic nerve this pupil is rather larger than its fellow as a rule, but the consensual reaction to light on the sound eye appears to be much increased, granted of course that the third nerve is intact Dilatation of the pupils with retained mobility is found sometimes in myopia and in conditions of impaired nerve tone *e g*, anæmia, it is also found in cases of disseminated sclerosis with optic atrophy, which rarely if ever leads to complete loss of sight in this disease Dilatation as a reflex to painful impressions has already been mentioned Unilateral dilatation may result from irritation of the cervical sympathetic in the presence of glands in the neck, pneumonia phthisis, chronic pleurisy, cervical ribs, thoracic aneurysm, &c, but it is rare from such cause it may also be due to syringomyelia, acute anterior poliomyehtis and meningitis affecting the lower cervical and upper dorsal part of the spinal cord and to pressure on the sympathetic fibres leaving the cord in the lower cervical and upper dorsal ventral

roots Many of these causes lead eventually to constriction of the corresponding pupil from paralysis of the sympathetic Temporary dilatation of one pupil is not very uncommon Unilateral dilatation with immobility may result from a blow on the eye (Chap XXI)

The pupils are small in babies and in old people When the pupils are small as under the influence of bright light, the relation to the centre of the cornea can be best seen the centre of the pupil is usually a little to the nasal side of the centre of the cornea Small pupils are rarely perfectly round A small immobile pupil should make us suspect old iritis with posterior synechiæ, and should lead to investigation with a mydriatic—homatropine for diagnostic purposes—to see if the pupil dilates regularly Bilateral small immobile pupils make us suspect disease of the central nervous system (*e g*, pontine hæmorrhage), further examination may show that the immobility is confined to reaction to light (*vide* p 94) A small sluggish pupil, with muddiness of the iris is associated with iritis, which may be primary, or secondary to corneal trouble

Very small immobile pupils suggest the use of drugs either locally, *e.g.*, eserine, or through the general system, *e g*, morphia

The chief causes of inequality of the pupils have already been mentioned incidentally As indicative of central nervous disease it is found in general paralysis and tabes

We must note carefully the nature of the contraction when the pupil reacts to light and especially if the constriction is well maintained (*vide* p 395)

Direct reaction to light does not eliminate the possibility of the patient being blind, *e g* in uræmia and post basic meningitis

The Lens The lens cannot be thoroughly examined without the assistance of the ophthalmoscope By inspection aided if necessary by focal illumination we note any opacities in the pupillary area The pupil may be blocked with iritic exudates (inflammatory pupillary membrane, blocked pupil)

Opacities in the lens itself are seen by oblique illumination as grey, white or yellowish patches According to their distribution and nature we diagnose the various forms of cataract, but our observations must always be confirmed and controlled by ophthalmoscopic examination The following example will show how easily one may be led astray When the light is concentrated by focal illumination upon the pupil of a person's eye the lens substance seems almost

at most we see a faint bluish haze If we examine the lens of
an old person in the same manner the haze is much more
pronounced , the lens substance in fact looks slightly milky
We might conclude that the patient has cataract Examina
tion with the ophthalmoscope will, however, show a perfectly
clear red reflex The explanation is that the lens substance
generally becomes more optically dense, i e , the refractive
index increases, as the person grows older (*vide* § 53) Now the
higher the refractive index of a substance the greater will be
the scattering of light from its surface The milkiness which
we see is due to rays of light which are reflected from the lens
and enter our eyes The more rays reflected the more will the
lens appear milky

If however, the white appearance is very pronounced and
especially if it is strictly localised to certain parts of the lens
substance, we may safely diagnose cataract A spot in the
centre of the pupil looking as if it were on the surface of the
lens, may be a pupillary exudate or an anterior polar cataract
Triangular spokes of opacity with their apices towards the
centre are indicative of senile cataract A very white appear
ance over the whole pupillary area suggests a total cataract ,
if it is yellow and the iris is tremulous we suspect a shrunken
calcareous lens

The Tension Last in the external examination, but by
no means of least importance, we test the tension of the walls
of the globe, which is increased when the intraocular pressure
is raised though not necessarily *pari passu* It is done in the
same manner as testing for fluctuation in other parts of the
body

Stand facing the patient, who is told to keep looking towards
his feet Place the index fingers of both hands side by side
and touching each other upon the upper lid, steadying them
by the other fingers lightly applied to the brow Keep one
finger quite still, pressing upon the globe through the lid Now
attempt gently to indent the globe with the other finger,
pressing directly downwards, concentrating the attention
meanwhile on the impression which is conveyed to the
stationary finger Repeat the process on the other eye

The student should practise this manœuvre on a number of
healthy eyes He will thus obtain a mental estimate of
what is to be considered normal tension—Tn In absolute
glaucoma the eye is usually stony hard , this condition is
generally indicated by the convention T + 3, a misuse of
numbers but one in common use The gradations of in

creased tension from Tn to T + 3 are usually indicated by the conventions T full (T +) T + 1, T + 2 Similarly the gradations of diminished tension are represented by T minus (T —), T — 1, T — 2, T — 3

Instruments known as *tonometers* have been devised for measuring the tension of the intact eye They are far less reliable than the manometer, which, however, cannot be used on the human eye The best tonometer for clinical use is that invented by Schiotz (Fig 74) With it the depth of the indentation in the cornea, anæsthetised with 1 per cent pantocain solution made by a weighted stylet is measured by a lever which travels over a scale There are four weights (5 5, 7 5, 10 and 15 gms) and the greatest accuracy is attained with the weight which gives a deflection of the lever of 2 to 4 mm The instrument is calibrated so that the equivalents of the readings in millimetres of mercury can be read off a chart The readings are inaccurate when transformed into pressures in millimetres of mercury, but the tonometer is certainly useful for comparative measurements e g , between the two eyes or between successive measurements on the same eye
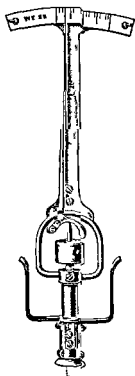
The Microscopy of the Living Eye The invention of the slit lamp by Gullstrand has rendered possible the examination of the anterior parts of the eye under considerable magnification by the binocular microscope The somewhat complicated technique militates against its routine use as a clinical instrument, but it has already added to our knowledge of anatomical and pathological conditions in the cornea, anterior chamber, iris lens and vitreous The most important results are to elsewhere under the appropriate headings Fig 75 shows

FIG 74

general view of the eye illuminated by a beam of light of moderate width coming from the slit lamp entering the eye from the left side   Optically homogeneous media appear quite black, structures like the cornea, lens, and suspended particles in the aqueous scatter the light   Hence, on the left of the diagram is seen the
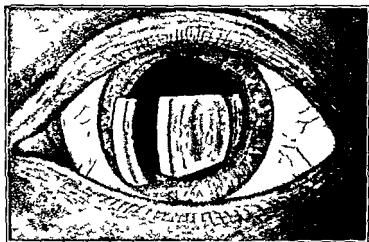
FIG 75 —Slit lamp illumination (Koby)

illuminated portion of the cornea forming a parallelepiped, the brighter area corresponding to the surface, the darker to the section of the cornea   The black space to the right is the anterior chamber   Then follows the "phantom" of the lens, in which can be distinguished the dim central interval, the Y and A which delimit the fœtal nucleus anteriorly and posteriorly, and the surfaces of the adult nucleus (*vide* p 9)   Still farther to the right is the faintly striated vitreous

Since minute details, *e g* particles floating in the aqueous, are revealed by the slit lamp, considerable experience in its use is necessary in estimating their pathological significance

CHAPTER VII

Ophthalmoscopic Examination

THE internal parts of the eye beyond the lens cannot be seen without the assistance of the ophthalmoscope A little consideration of the optical conditions of the eye will show the reason

Under ordinary circumstances the pupil looks black, and no red reflex, much less a clear image, is obtained from the fundus If, as in Fig 76, there is a source of light, L, in front of the eye, and the eye is focussed upon it or accommodated for it, the light and a spot upon the retina are conjugate foci, *i e*, the image of the spot of light is a spot on the retina

Reversing the direction of the rays, all rays from the illuminated spot of the retina are brought to a focus at the source of light Therefore no rays will enter an observing eye unless it is situated actually at the source of light The problem solved by Babbage (1848) and rediscovered by von Helmholtz when he invented the ophthalmoscope (1851) was practically that of making the observing eye at the same time the source of illumination of the observed fundus

If the eye is not focussed for the source of light the conditions are different, and some slight luminosity of the pupil may be seen This is one cause of luminosity in the pupils of the hypermetropic eyes of young children and most carnivora Extreme hypermetropia is also the cause of the so called amaurotic cat's eye, which is due to detachment of the retina, glioma of the retina, &c In these cases the retina is pushed forwards and the fundus at this spot becomes highly hypermetropic, the reflex from the pupil being often the first symptom noticed The same principle applies to the reflex

from the eye after the lens has been removed by extraction of cataract

In hypermetropia the conjugate focus of the source of light, L, is a point, l, behind the retina (Fig 77)   Hence the emergent rays from the illuminated area of the fundus are divergent, as if coming from l Therefore an observing eye situated anywhere within the area $l_1\ l_2$ of the cone of emergent rays will catch some of them, and the pupil of the observed eye will appear feebly illuminated   Under these circumstances it is not necessary for the observing eye to occupy the exact position of the source of light, but only a spot in its immediate neighbourhood   On the same principle, the extremely hyper metropic retina in glioma retinæ, &c can be seen well by focal illumination

In high myopia the emergent rays are strongly convergent
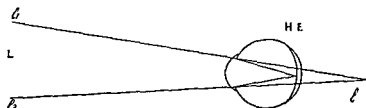
Fio 77

and become divergent after coming to a focus at the remote point (Fig 80)   Beyond this point some of the divergent rays may enter an observing eye suitably situated and the observed pupil appears illuminated

The luminosity of albinos' eyes is due to light entering the eye, not only through the pupil, but also through the iris and sclerotic   That this is the true explanation is shown by the fact that the pupil looks black, if it is observed through a small hole in an opaque screen   A small amount of light passes through the sclerotic in the normal eye

It will help us to understand the principles of the ophthalmoscope if we say a few words about its historical development   The ophthalmoscope was invented by Babbage in 1848, but its importance was not recognised, and it was rediscovered by von Helmholtz in 1851   The original ophthalmoscope of von Helmholtz was merely a plane plate of glass (Fig 78)   A source of light was placed beside the observed eye and the glass plate obliquely in front of it, so that a portion of the light was reflected from the surface of the plate into the

eye On looking through the transparent plate an observer could now receive some of the rays from the fundus into his own eye, and thus obtain an image of the illuminated fundus Since but a small proportion of the light received upon the plate is reflected at its surface the illumination is feeble Nevertheless, the principle is worth bearing in mind as a ready means of getting a view of a fundus in the absence of a more satisfactory ophthalmoscope Moreover, an error of refraction in the observed eye may be obviated by using the corre-
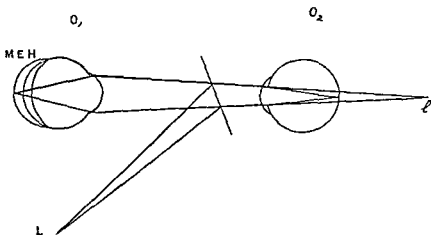
FIG 78—Diagram of von Helmholtz' ophthalmoscope O_1, observed eye , O_2 observer s eye , L, source of light , l image of L formed by the plane mirror—immediate source of light , M E H, relative positions of retina in myopia, emmetropia, and hypermetropia respectively, showing the relative sizes of the areas of retina illuminated in each case

sponding spectacle glass of the patient as the ophthalmoscopic mirror

Von Helmholtz next increased the amount of light reflected by superposing three plane plates The back of the glass was next converted into a more powerful mirror by silvering it, leaving a small portion unsilvered or leaving a hole in the mirror, through which the observer might look The illumination was still feeble, since the rays reflected by a plane mirror are divergent (vide p 25) Ruete therefore (1852) introduced the perforated concave mirror which still holds the field The final modification was the addition of a battery of small lenses of various strengths, which might be brought into position behind the aperture The multitudinous forms of

" refraction ophthalmoscopes " are merely various mechanical contrivances for doing this most conveniently *

There are two chief methods of ophthalmoscopic examination, the direct method (v Helmholtz, 1851) and the indirect method (Ruete, 1852)   The ophthalmoscope is provided with two mirrors, one a small one, slightly tilted, for the direct method, the other a large one, not tilted, for the indirect method   Both are concave, the former with a focal distance of 30 cm , the latter of 10 cm   It is an advantage to have also two plane mirrors corresponding with these , with such a four mirror ophthalmoscope the surgeon is fully equipped for every detail of ophthalmoscopy and retinoscopy

The importance of system in his methods is so often impressed upon the student that he is liable to underrate it through sheer reiteration   It will perhaps suffice to say here that in using the ophthalmoscope he will inevitably come to grief unless he pursues his examination on a well ordered plan   The order of examination should be as follows

(1) Preliminary examination with the mirror alone at a distance of about 1 metre from the patient ,

(2) Examination with the mirror alone at a distance of about 20 cm (reading distance) from the patient , this is sometimes called the distant direct method ,

(3) Examination by the indirect method ,

(4) Examination by the direct method

The following facts will impress upon the student the reasonableness of this procedure   By (1) we obtain knowledge *of the nature of the refraction of the eye under examination* , this will prevent many little difficulties when we come to closer quarters   By (2) we see any gross changes, especially opacities in the refractive media , these may be made at once evident by this method, whereas they may be very puzzling

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* The student is advised to procure a good ophthalmoscope at the outset of his clinical work in the medical wards   The cheaper forms are not only waste of money, but are a perpetual source of annoyance   The modification of *Couper s ophthalmoscope generally known as Morton s, is most strongly recommended*   In recent years various self luminous ophthalmoscopes have been devised   In most of these half the aperture of the ophthalmoscope is used for illuminating the fundus from a small electric bulb contained in the instrument the other half being used for observation   The lamp is run off a small *dry* battery *which may be placed in the handle of the ophthalmoscope* In the polarising ophthalmoscope the light is plane polarised thus eliminating the troublesome corneal reflex (*vide* p 109) Self luminous ophthalmoscopes are particularly useful for examining bed ridden patients   They have the disadvantage that they are seldom suitable for examination by the indirect method—*a method which should never be omitted before using the direct method*

if first observed by (3) or (4)   In addition, we shall see the
details of any very hypermetropic part of the fundus, such as
a detached retina or glioma of the retina, these also are by
no means difficult to miss by (3) and (4)   By (3) we get a
general view of the fundus—the largest possible area under
moderate magnification, it is exactly comparable to micro-
scopic examination with a low power   By (4) we examine
details under a higher magnification, it is exactly comparable
to microscopic examination with a high power

The student should begin by taking a patient whose pupils
have been dilated with atropine e g a boy of twelve or
fourteen who has come for the correction of his refraction
The atropine will have had the additional advantage of having
paralysed the patient's accommodation   The observer should
know his own refraction

The patient is taken into the dark room and seated beside
the light   The light is placed to the side which is to be
examined, but well behind the level of the patient's face, the
eye should be as much as possible in darkness   The observer
sits facing the patient, about a metre from him   He reflects
the light from the large ophthalmoscope mirror into the eye
meanwhile looking through the sight hole   This requires a
little practice, but is quickly mastered   When the light falls
on the eye he notices a red reflex from the pupil   There ought
to be no black spots in the pupillary area, but either a uniform
red reflex or obscure details of the fundus   By tilting the
mirror to and fro in various directions he can obtain an
approximate idea of the refraction of the eye (vide p 107)

The observer now stands up and approaches the patient
until his eye still with the large mirror, is about 9 inches from
the eye under observation   He can now see the cornea and
iris clearly, and can confirm any points which he has made out
previously by the external examination

He then sits down again at about a metre from the patient
Still keeping the light upon the eye with the large mirror,
with his left hand he holds the large convex lens, which he
will find in the ophthalmoscope case, close in front of the eye
He will be wise not to hold the lens absolutely vertical but
to tilt it very slightly   He will probably see only the magni
fied iris through the lens   He now watches the red reflex
from the pupil, and slowly withdraws the lens from the eye
towards himself   At a certain point he will see an inverted
image of the fundus quite clearly   The indirect method
requires also some practice but the amount required may be

much diminished and much greater accuracy attained if the optical conditions under which the examination is made are thoroughly understood These will be explained immediately

Having obtained a good general view of the fundus, the observer again approaches the patient He now uses the small tilted mirror of the ophthalmoscope The mirror is tilted so that it faces towards the light Looking through the sight hole he first gets the light upon the eye, this is best effected from a short distance away When the light is well on the pupil and the observer can see the red reflex he approaches slowly nearer and nearer, watching that the light does not leave the pupil, until his brow is almost or quite touching the patient's brow If now both the patient and the observer are emmetropic the inexperienced observer will probably see the details of the fundus only indistinctly He should then turn up with his index finger applied to the milled disc on the back of the ophthalmoscope successively stronger concave glasses (usually marked with white numerals) He will then probably see the fundus quite clearly The image is erect, i e, the opposite of that by the indirect method Here again practice is needed, and a knowledge of the optical conditions is quite essential

We will now consider the chief features which are to be learnt in each stage of the examination and how they are to be learnt

I Preliminary Examination with the Mirror at 1 metre We will suppose that the observer is emmetropic or that his refraction has been corrected, and that the accommodation of the observed eye is at rest or paralysed In examining the right eye the patient is told to look at the observer's right little finger which is held up, this is easily done while holding the ophthalmoscope In examining the left eye the patient is told to look at the observer's left ear In this manner the optic disc which lies a little to the nasal side of the posterior pole of the eye is brought into the observer's line of vision When the optic disc is opposite the pupil we shall notice from a distance of 1 metre that the red reflex becomes paler or even whitish

If the eye is highly hypermetropic or myopic we shall see some details of the fundus e g a few vessels running across the reflex The explanation is easy from what we have already learnt

Consider first the hypermetropic eye If we think of two spots on the retina, say at opposite edges of the disc, the rays reflected from these points will form two bundles of divergent

rays when they leave the eye just as if they came from the corresponding virtual remote points behind the eye (Fig 79) The greater the distance from the eye, the greater will be the area over which these divergent rays will spread, so that at 1 metre some of the peripheral rays of each pencil will enter the observer's eye By a slight effort of accommodation the observer will be able to bring these divergent rays to a focus on his retina so that he will obtain a clear image of each point, and necessarily also of the intervening region It is exactly as if the eye were taken away and the two points were situated at the remote points Hence the image will be erect

If the observer now shifts a little to one side the observed eye remaining stationary, more rays will enter his eye from the neighbourhood of the opposite point and less from the
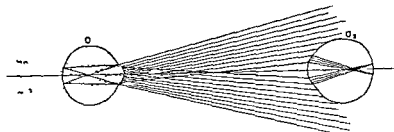
Fig 70—Examination with the mirror at 1 metre O₁ observed eye which is hypermetropic O₂ observer's eye emmetropic but accommodated for the divergent rays from O₁

neighbourhood of the point on the same side as that to which his movement is directed Although the points remain stationary more of the fundus on the opposite side and less of the fundus on the same side will be seen Hence the points will seem to move in the same direction as his own movement The observer mentally regards the very sharp outline of the pupil as a fixed object of comparison and as more of the fundus on the opposite side comes into view, whilst a corresponding amount on the same side disappears thus is mentally interpreted as a movement of the image in the same direction

If, therefore, when the light is reflected into the eye at a metre distance we see vessels in the pupillary reflex and if they appear to move in the same direction when the head is moved slightly to one side we conclude that the eye is hypermetropic

Consider now the myopic eye (Fig 8)) Here the emitted rays from the two points will be strongly convergent in each case, and a real inverted image of the points and intervening

area will be formed at the remote point of the eye, $t\,e$, between the observer and the observed eye The rays will diverge from this image, and the effect will be exactly the same as
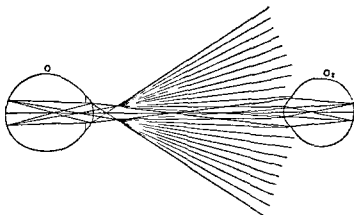
FIG 80 —Examination with the mirror at 1 metre O_1 observed eye which is highly myopic O_2 observer s eye emmetropic but accom modated for the divergent rays from the far point of O_1

if there were an actual inverted object in this position If the myopia is sufficiently high, the image will be beyond the observer's near point, so that he will be able to accommodate for it If he moves to one side he will see more of the observed
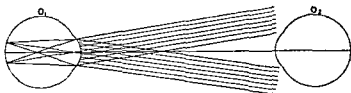
FIG 81 —Examination with the mirror at 1 metre O_1 observed eye which is emmetropic O_2 observer s eye none of the rays from the widely distant points on the fundus of O_1 enter O_2 If the points are close together the rays of the two bundles will be nearly parallel and would form a clear image on the retina of O_2 if the accommodation of O_2 were almost completely in abeyance

fundus on the same side and correspondingly less on the *opposite side so that the fundus will appear to have moved* in the opposite direction

If, therefore, when the light is reflected into the eye at a metre distance we see vessels in the pupillary reflex, and if they appear to move in the opposite direction when the head

is moved slightly to one side, we conclude that the eye is myopic

What will happen in emmetropia (Fig 81) or low myopia, for the effect will be similar ? Here the rays passing out of the eye from the two points will be parallel or very slightly convergent, and their direction will be that of their axes, which is the continuation of the lines joining the points with the nodal point of the eye As these axes constantly diverge from one another, the observer at a distance of 1 metre cannot receive portions of both pencils of rays upon his own pupil, consequently he cannot obtain a clear image of the whole intermediate region between the spots He may get a clear image from two spots very close together, but only if his accommodation is almost completely suspended, so that nearly parallel rays are brought to a focus upon his retina

The same reasoning applies to low hypermetropia, for here the remote point of the eye is so far behind the retina that the rays diverge very little when they leave the eye, so that they are almost parallel

If, therefore, when the light is reflected into the eye at a distance of a metre we see only a red reflex in the pupil, without any details, we conclude that the eye is either emmetropic or has only a low degree of ametropia

A still simpler means of discovering the condition of the refraction is as follows Still throwing the light into the eye with the large concave mirror we tilt it gently in various directions We shall see a shadow move across the pupil, if the shadow is very dark there is considerable error of refraction If it moves in the opposite direction to that in which we move the (concave) mirror the eye is hypermetropic , if in the same direction it is myopic This method is used for correcting refraction and we shall consider it in detail later (see Retinoscopy)

II Preliminary Examination with the Mirror at the convenient distance for near vision (22 cm) At this distance the observer will be most suitably situated for distinct unaided vision, and he will be able to examine the superficial parts of the eye more accurately If he is presbyopic he will naturally have to correct his presbyopia, and he may have to use a convex lens if he is strongly hypermetropic If he is very myopic he will have to approach closer

The advantages of a preliminary examination in this manner are (1) the recognition of opacities in the refractive media , (2) the recognition of a detached retina or other substance not

far behind the lens , (3) the confirmation of the results found by the external examination

(1) *The diagnosis of opacities in the refractive media* If the eye is normal there will be a red reflex from the pupil If there is any opaque body in the course of the rays reflected from the fundus it will stop these rays and will therefore appear black The whole field may be black, as when the lens is entirely opaque, or when there is blood in the vitreous In the latter case oblique illumination will show the red blood behind the transparent lens if it is sufficiently far forward in the vitreous the blood looks red in this case because of the light reflected from its surface

Opacities vary in shape, size, and position We are particularly concerned to discover their position, as this frequently gives the key to their nature

The first point to determine is whether the opacity is movable This is done by telling the patient to move his eye in different directions—towards the ceiling towards the floor, to the right, to the left—and then to look straight forward A floating opacity will then continue to move after the eye is brought to rest It must therefore be either in the aqueous or vitreous In the former position it can be seen and diagnosed by other methods If it is in the vitreous and is freely movable we also learn that the vitreous is fluid, which is not its normal consistency If the opacity moves only with the eye it may be in the cornea, lens, or vitreous, which, under these circumstances, will have its usual viscous consistency

The next point is to determine its exact position This is effected in the preliminary examination with the mirror alone by *parallactic displacement*

In Fig 82, if 4 is the centre of rotation of the eye, and if there are opacities at 1, 2, 3, 4, 5, then, when the eye is rotated a small amount, the opacities, 1, 2 and 3, in front of the centre of rotation will move in the direction of rotation, and 5, behind the centre, will move in the opposite direction, while 4, at the centre, will not move It is obvious that the amount of movement will be greater the farther the opacity is from the centre of rotation Now, we have no means of defining the centre of rotation by ophthalmoscopic examination, but all the movements will be referred to the edge of the pupil for comparison (*vide* p 165) If the observer is situated at A, all the opacities will appear as a single spot in the centre of the pupillary reflex If he shifts his position to B, or if the eye is rotated a corresponding amount in the opposite direc

tion, the opacity 2 will remain in the centre of the pupil, whilst 1 will appear to move towards one edge of the pupil, and 3, 4 and 5 towards the opposite edge, 5 being lost entirely behind the iris

Hence we deduce the rule that if the eye is moved slightly in a given direction opacities in the pupillary plane will appear stationary, those in front of that plane will move in the same direction, and those behind will appear to move in the opposite direction, the amplitude of apparent movement being a rough indication of their distance from the pupillary plane

There is another guide which we may make use of, viz, the corneal reflex. This is the image of the mirror formed by
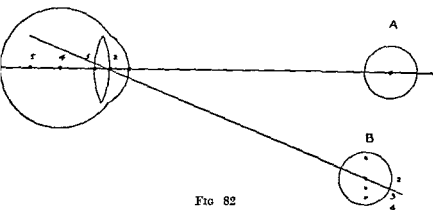
Fig 82

the cornea. With the ordinary convex mirror it is a virtual image (*vide* p 26) situated about 4 mm behind the anterior surface, i e, a short distance behind the anterior surface of the lens (behind 2 in Fig 82) The centre of curvature of the cornea is situated 8 mm behind its anterior surface, i e, less than 1 mm behind 3 (Fig 82) The corneal reflex will always cover this latter spot, the centre of curvature of the cornea, no matter what the position of the eye Hence an opacity situated here will always be covered by the corneal reflex, opacities in front of the centre of curvature move in the same sense with regard to the reflex as the eye moves, and opacities behind it move in the opposite direction to the movement of the eye Therefore, in Fig 82, in the first position of the eye, the opacities 1, 2, 3, 4, 5, will all appear in the centre of the corneal reflex (A'), in the second position they will appear as in B', so that an opacity at the posterior

pole of the lens will scarcely leave the edge of the reflex, whereas an anterior polar opacity will move much farther from it

One peculiar apparent opacity is seen by the mirror alone, and this method affords the surest means of discovering the defect   This is the edge of a dislocated lens, or the notch in the edge of the lens in congenital coloboma of the lens   When the edge of the lens crosses the pupillary area it is seen as an intensely black crescent sharply defined peripherally but merging centrally into the clear red reflex   The reason of this *appearance is that the whole of the light reflected from the fundus which falls upon the extreme edge of the lens is totally reflected within the lens ,   none of it leaves the eye, so that none can enter the observer's eye

We not infrequently meet with very fine opacities, especially in the vitreous   If we use a concave mirror and a bright light we shall probably fail to see them, the reason being that these very delicate opacities are partially transparent, so that if the light is very bright some passes through them and contrast is reduced   Contrast is further reduced by reflection of light from their surfaces   They are as it were, drowned in light   In order that we may be sure of not missing fine opacities the best method to adopt is to use a plane mirror   The rays reflected from a plane mirror are divergent (*vide* p 25) , hence less light enters the eye   If we have no plane mirror available the light should be reduced, but this is not so satisfactory   We may increase our chances of seeing the specks if we place a convex lens behind the mirror, which will have the effect of magnifying them (Fig 21)

Besides a detached retina we shall also be able to see anything else in a similar position, *e g*, a tumour pushing the retina forwards, or a tumour of the retina itself (glioma), and so on

None of these will be seen unless they are pushed forwards very considerably, hence we must not asseverate the absence of a detached retina, &c, if we fail to see it by this method

(3) *Confirmation of the results found by the external examination* We are able by this method not only to confirm the results previously arrived at by external examination, but also to supplement them by important subsidiary information Thus we are able to map out the limits of opacities in the lens much more accurately, since they now appear black on a red background, and as has already been shown we can determine their exact position with much greater precision

We may have noticed a black spot in the iris in a case with the history of a foreign body having gone into the eye It is probable that the foreign body has passed through the iris, and that the black spot is a hole The examination with the mirror often at once settles the question, for if there is a hole we shall be able to find some position in which a red reflex can be seen through the hole The absence of a red reflex does not prove the absence of a hole, for the lens may be opaque behind the hole

The following is a somewhat similar example We have noticed a black patch at the ciliary margin of the iris, convex in outline towards the pupillary margin It may be a melanotic sarcoma of the ciliary body growing forwards and implicating the iris or it may be a separation of the iris from its ciliary attachment (iridodialysis) In the latter case it will be possible to obtain a reflex through it by the mirror, whereas in the former it will be opaque

We have said that by this method opacities in the refractive media appear black Superficial opacities, however, such as those in the cornea and near the anterior surface of the lens, can be seen in their natural colours by approaching still nearer to the eye Under these conditions more light is reflected from the surface of the opacities and some of it enters the observer's eye It will be objected rightly that now we shall be within our near distance and consequently shall not be able to see anything clearly This is true, but it can be obviated by assisting our accommodation by putting up gradually stronger convex glasses behind the ophthalmoscope mirror as we approach the eye This has the additional

advantage of magnifying the opacity If we approach very
close to the eye and place a $+ 20$ D lens behind the mirror we
shall see the opacities highly magnified This glass will be
acting very much like an ordinary magnifying glass, so we
shall have to focus it in much the same manner We therefore
start a little distance from the cornea and watch carefully as
we get nearer and nearer , there will come a point when the
opacity is very clearly defined

Suppose now that under the same conditions, with the
$+ 20$ D lens in the position for seeing the cornea we wish to
*examine an opacity near the surface of the lens it can be done
in two ways* We may continue to approach still nearer until
it comes into focus , or we can use a weaker lens, retaining our
original position
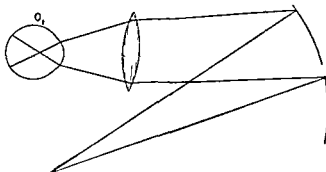
FIG 83—Indirect method. Illumination of the fundus showing the
course of rays from the source of light to the mirror through the lens
and through the eye and the area of the field of illumination

original position The weaker lens is most easily produced by
moving up stronger and stronger concave lenses in front of the
$+ 20$, until the opacity is accurately focussed This is made
possible in most ophthalmoscopes by having a $+ 20$ D lens
set in a disc which lies behind the sight hole the lens can be
turned into position when required, and does not interfere with
the use of the other lenses at the same time The opacity in
the crystalline lens will, of course, not be quite so highly
magnified by the second as by the first method

III The Indirect Method The indirect method of exami-
nation with the ophthalmoscope consists essentially in making
the eye, whatever be its refraction, highly myopic by placing
a strong convex lens in front of it (Figs 83–85) The
effect of this will be to form a real inverted image of the
fundus between the observer and the convex lens, as will be

easily understood from the accompanying diagrams If the eye is already myopic the convergent rays which come from any point on its fundus will be made still more convergent by the lens, and the inverted image which is always formed in myopia will be brought close to the lens If the eye is emmetropic the parallel rays emitted will be made strongly convergent, and where they cross the inverted image will be formed If the eye is hypermetropic the rays will still be made convergent, for the lens used is so strong that the divergence in hypermetropia is never strong enough to prevent it

It will be seen that with the same lens the inverted image is formed at different distances beyond it according to the refraction of the eye If the lens is kept at a constant distance from the eye, e g , its own focal distance the emmetropic image will be formed at the focal distance of the lens beyond it the myopic will be nearer to the lens, the hypermetropic farther from it (Fig 85)

Fig 84—Indirect method Emergent rays from the fundus showing the formation of the image In the figure the lens is situated at the anterior focal plane of the eye the rays which are parallel inside the eye therefore pass through the optical centre of the lens The rays which pass through the nodal point of the eye are rendered convergent by the lens The point where these two systems of rays cross give the position of the image which is seen to be inverted

In all cases the image is magnified, the amount of magnification depending upon the refraction of the eye, the strength of the lens, and its distance from the eye With a + 13 D the fundus of an emmetropic eye is magnified about five times

One of the greatest difficulties in using the indirect method is the group of reflexes formed by the eye and the surfaces of the lens We have seen that the cornea forms a reflex of the mirror when it is used alone This reflex, when seen through the convex lens, is magnified, so that it may cover the pupil and prevent anything behind being seen But the surface of the lens towards the observer acts like another convex mirror and forms another reflex situated behind the lens Similarly the surface of the lens near the patient acts like a concave mirror and forms a reflex on the observer's side of the lens These reflexes are very troublesome, but they may be got out of the way by a little manœuvring It has been said that the two lens reflexes, which are the most troublesome, are images

of the mirror formed on opposite sides of the lens   If we tilt the lens a little it will be found that these reflexes move in opposite directions, and we can look quite comfortably between them   We must be careful not to tilt the lens more than is necessary, because if we look obliquely through a tilted lens objects appear distorted   in fact we produce one type of astigmatism   The distorted image of the disc produced in this manner may be attributed to astigmatism in the eye, when none is really present

Another difficulty which the beginner usually experiences is due to getting too close to the patient   If he understands the position of the image which he is looking for as described above, he will discover why he can see no sharp image when
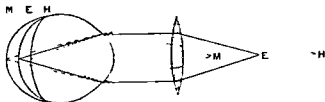
Fig 80 —Indirect method. Position of the image according to the refraction of the eye   In this figure the lens is situated at its own focal distance from the cornea   In emmetropia the parallel emergent rays therefore cross at the principal focus of the lens E   In myopia the convergent emergent rays cross nearer to the lens than its principal focus viz   at M   in hypermetropia the divergent emergent rays cross farther from the lens than its principal focus viz , at H

he is too close to the patient   Most people using the indirect method think that they are looking at the pupil   As a matter of fact, when the fundus is seen clearly, they are not accommodating for the pupil, but for the real image of the fundus, which is in the air somewhere between the lens and the observer   Now we can only see an object clearly with the unaided eye if it is at a convenient distance away   Consequently, if the observer gets so close to the patient that he is less than the distance of his near point from the aerial image he cannot see it clearly

If we like to do so we can get over this difficulty and still remain closer to the patient   In order to do so, the observer must help his accommodation by putting up a convex lens in front of his eye   If we put up a + 1 D or + 2 D behind the ophthalmoscope mirror, we shall not only see the image clearly at a shorter range, but we shall also magnify it, an additional advantage

As regards the position of the convex lens before the patient's eye, there is a considerable range over which we can see the fundus quite well, but some positions are better than others In practice we find the best position by putting the lens close to the eye to start with, steadying it by the little finger applied to the patient's brow, and gradually bringing it farther away from the eye until the best position is obtained

Theoretically, from the point of view of the maximum field of fundus seen, the best place for the lens is its own focal distance from the patient's pupil But this is the very worst place from the point of view of the corneal reflex   The latter is situated near the level of the iris (4 mm behind the cornea, *vide* p 109) If the convex lens is at its focal distance from it, the rays from this image will be made parallel by the lens, *i e*, the reflex will fill the whole area of the lens, and we shall see nothing else Hence the best position for practical purposes is either nearer to or farther from the eye than this position   We shall see later that a convenient distance is when the lens is at its focal distance from the anterior focus of the eye Here, slight tilting of the lens, besides shifting the lens reflexes out of the way, will also move the corneal reflex and the image of the fundus in opposite directions, and so get the corneal reflex out of the way

We can tell by the indirect method whether the eye is emmetropic or ametropic by observing the effect of shifting the lens on the size of the image of the fundus   We use the disc as the best guide, getting it into the field by telling the patient to look in the appropriate direction, *i e*, towards the raised right little finger when examining the right eye, towards the left ear when examining the left

Place the lens close to the eye and gradually bring it farther away If the image of the disc does not alter in size the eye is emmetropic , if it gets smaller the eye is hypermetropic , if it gets larger the eye is myopic

If we understand why this is so, we shall be able to remember what happens in each case Imagine two points, *a* and *b*, upon the fundus, *e g* , upon opposite edges of the disc (Fig 86) If they are illuminated, one of the many divergent rays emitted by each must be parallel to the axis   These two rays, when they pass out of the eye, will cross at the anterior focus of the eye, whatever its refraction may be, as long as the error is one of undue length or shortness (*axial ametropia*) They will cross at the anterior focus because they are parallel to each other before refraction Now, suppose that the convex lens used in the

indirect method is situated at its focal distance from the anterior focus of the eye   These two rays, after they have crossed, will meet the convex lens, and since they come from the focus of the lens they will be parallel to each other after refraction   As we have already seen (p 113), under such circumstances the image of the fundus is formed in emmetropia at the focal distance of the convex lens (F^1) from it (E)   In myopia the image will be nearer the lens (M), in hypermetropia farther away (H)   The two rays which we have been considering must represent the images of the two points on the fundus   Hence the distance between them after refraction by the eye and by the lens will give the size of the image of the portion of fundus between *a* and *b*   We see therefore that when the lens is at its own focal distance from the anterior focus of the eye the magnification of the image
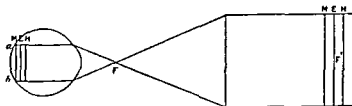
Fig 86

is the same in emmetropia, in axial myopia, and in axial hypermetropia

If the lens is nearer the eye than the above distance (Fig 87), the rays under consideration will diverge after refraction by the convex lens   Hence, if the lens is less than its own focal distance from the anterior focus of the eye, the magnification is greatest in axial hypermetropia, least in axial myopia, and intermediate in emmetropia   Conversely, if the lens is farther from the eye, the rays under consideration will be convergent after refraction by it   Hence, if the lens is more than its own focal distance from the anterior focus of the eye, the magnification will be greatest in axial myopia, least in axial hypermetropia, and intermediate in emmetropia

In *curvature ametropia*, such as we meet with in astigmatism, the results are not quite the same   but they are easily deduced if we remember that there are now two anterior foci to the eye, one for each meridian   There are also two nodal points   When the lens is at its focal distance from the cornea the magnification is the same in emmetropia and any ametropia of curvature   In these circumstances the disc appears circular   If the lens is nearer the eye the image is elliptical, with its long axis in the less refractive meridian, *i e*, generally horizontal   If the lens

is farther from the eye the long axis is in the more refractive meridian, i e, generally vertical   As mentioned before, it is essential that the lens should be held almost vertical as any inclination makes it itself astigmatic   If the disc is really oval, as in high myopia, the axis of the ellipse will of course remain unaltered

Ametropia of index of refraction occurs in old age   Aphakia, the condition when the lens has been removed, may be considered an extreme form of index ametropia   Here the position of the nodal point remains invariable, and if the convex lens is at its focal distance from this point the image is the same size in emmetropia and ametropia of index of refraction   If the lens is moved closer to the eye the image increases in hypermetropia and diminishes in myopia, while it remains the same in emmetropia
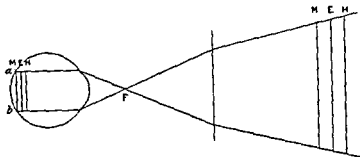
FIG 87

Since the image is formed at a considerable distance beyond the focus of the lens in the high hypermetropia of aphakia it is convenient to use a stronger lens, e g , + 18 D

Differences of level of two points near each other on the fundus are made very evident by parallactic displacement in the indirect method   Thus, in Fig 88, if there are two spots, a and b, at different levels in the fundus, e g , on the edge of the disc and at the bottom of a glaucoma cup, when the lens is shifted slightly so that its optical centre moves from o_1 to o_2, the images of a and b will move from a_1 to a_2 and b_1 to b_2 It is of historical interest that this displacement was at one time wrongly interpreted, so that a glaucomatous cupping of the disc was diagnosed as a swelling

IV. The Direct Method   In the direct method the observer approaches as close as possible to the patient's eye (Fig 89) If the eye is hypermetropic the emergent rays will be divergent, as if coming from the virtual remote point behind the

eye   Owing to the short distance between the eyes a large
pencil will fall upon the observer's pupil, and may be brought
to a focus upon his retina if he makes a suitable effort of
accommodation   If he is presbyopic, or if his accommodation
is relaxed, he will only obtain a clear image by placing a
convex lens behind the sight-hole of the mirror (Fig 90, H)

If the observed eye is emmetropic the emergent rays will
be parallel, and consequently can only form a clear image upon
the observer's retina if his accommodation is absolutely
relaxed (Fig 90, E)—unless, he counteracts the amount
of his accommodation by a corresponding concave lens in
front of his eye (*vide* p 119)

If the observed eye is myopic the emitted rays are conver
gent   If the myopia is moderate the real image of the fundus
at the far point of the eye will be behind the observer's head,
i e   he will catch the convergent rays before they have come to
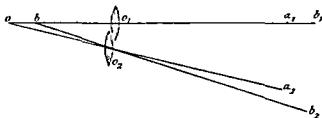
Fig 88 —Indirect method   Parallactic displacement

a focus   These convergent rays, entering his emmetropic eye,
are brought to a focus in his vitreous , hence he cannot possibly
obtain a clear image unless he counteracts the convergence
by an equivalent concave lens behind the mirror (Fig 90, M)
If the observed eye is very highly myopic its punctum remo
tum will be situated somewhere in the space between the eye
itself and the observer's retina, and it may be in such a position
that it is impossible to obtain a clear image with any correction
For example, the remote point may be just behind the sight-
hole of the mirror   Here it is too close to be accommodated
for, and no correcting glass situated at the same position will
have any effect upon the rays, for they will nearly all pass
through the optical centre of the lens   The practical outcome
of this discussion is to get as close to the eye as possible

Much stress is generally laid upon the necessity and the
difficulty of relaxing one's accommodation in examination by
the direct method   It is difficult to relax the accommodation

entirely when the eye is apparently close to the object looked at The observer should try to think that he is looking at a very distant object, but even then, as soon as he directs his attention to details of the picture, he is almost certain to accommodate It is best for the beginner not to worry himself about this point if he cannot see an emmetropic fundus clearly let him put up minus lenses until he does After he has acquired facility in seeing anything at all it will be soon enough for him to grapple with this difficulty

The image by the direct method is always erect Thus, in hypermetropia it is exactly as if the observer were looking at an actual object situated at the remote point of the eye *i e* some distance behind the eye In myopia the converging
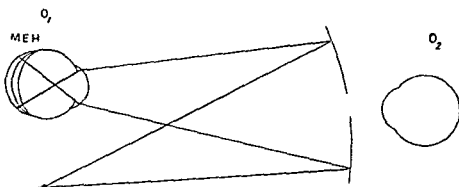
Fig 89—Direct method Illumination of the fundus showing the course of rays from the source of light to the mirror and through the eye also the area of the field of illumination Compare with Fig 83

rays are caught before they cross, they are made suitably less convergent by the correcting lens behind the mirror, so that again an erect image is seen In emmetropia the emergent rays are parallel and are, therefore, also caught before they cross—at infinity , hence again, an erect image is seen

The image is always magnified, and it is magnified more than by the *indirect method* In emmetropia the fundus is seen magnified about fifteen times In hypermetropia it is magnified less and in myopia more than in emmetropia

The field of ophthalmoscopic vision by the direct method, *i e*, the area of the fundus which can be seen, varies with the distance of the observer from the eye and with the refraction of the eye It increases as the eye is approached—another *reason for getting as close to the eye as possible* It is greatest in hypermetropia, least in myopia and intermediate in emme-

tropia. Thus, we see the largest area, least magnified, in hypermetropia, and we see the least area, most magnified, in myopia.

In astigmatism the magnification is greatest in the more myopic meridian, and least in the more hypermetropic. In the usual form of astigmatism the image of the disc is an ellipse with the long axis vertical—the opposite of the usual image by the indirect method, with the lens near the eye (*vide*
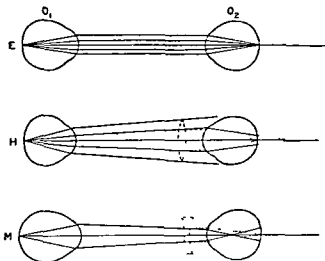
Fig. 90—Direct method. Emergent rays from the fundus of the observed eye, O_1, showing the formation of the retinal image on the retina of the observer's eye, O_2. In emmetropia, E, the emergent parallel rays are brought to a focus on the retina of O_2, if the accommodation of this eye is absolutely at rest. In hypermetropia, H, the emergent divergent rays are brought to a focus on the retina of O_2, either by means of accommodation or by placing a convex lens in front of O_2. In myopia, M, the emergent convergent rays can only be brought to a focus on the retina of O_2 by placing a concave lens in front of O_2.

p. 116). It is obvious that there can be no clear image of the whole field by the direct method in astigmatism. *Only lines perpendicular to the meridian which is corrected are seen clearly.* Lines in any meridian other than the two principal ones cannot be seen clearly by any spherical correcting glass, but only by a cylindrical lens or combination of a spherical and a cylindrical.

From what has been said it is obvious that the correcting lens behind the sight-hole of the mirror also represents the

spectacle glass which will be required to correct the refraction if it is placed in the same position Thus, of course is only true if the observer is emmetropic, or has his refraction corrected, and if his accommodation is quite at rest Since it is difficult to relax the accommodation completely, this method of determining any error of refraction should only be used as a rough estimate, unless the observer is an expert

If there is a difference in level between two points on the fundus, *e g*, the edge of the disc and the bottom of a glaucoma cup, it is made manifest by the direct method also by parallactic displacement If we focus the edge of the disc and then move slightly to one side the edge of the disc will appear to move over the bottom of the cup, *i e*, it moves in the opposite direction An object farther forward, therefore, moves in the opposite direction to the movement of the observer's head

The difference in level can be accurately measured In the example given, the bottom of the disc will be relatively myopic to the edge, since it is farther away from the back of the lens If the eye is emmetropic and the edge of the disc can be seen clearly without the assistance of any correcting lens we shall require a concave lens to see the vessels at the bottom of the cup clearly It can be proved that *if the correcting lens is at the anterior focus of the eye* a difference of 3 D is equivalent to 1 mm difference of level We must get as close as possible to the eye when measuring differences of level, because only then are the conditions of accuracy fulfilled If, with the observer's accommodation at rest, he sees the edge of the disc clearly with no correcting lens, but requires — 3 D to see the bottom clearly, he knows that the bottom is 1 mm behind the edge He will of course see the bottom clearly with a higher concave lens if he counteracts the excess by accommodating hence he must be careful to choose the lowest minus lens

Similarly projections forwards can be measured Here the observer chooses the highest convex lens with which he can see some well-defined point on the top of the eminence The same rule that 3 D is equivalent to 1 mm holds good Suppose, for example, that he is measuring the swelling of the disc in a case of optic neuritis He first finds the highest convex glass with which he can see clearly a retinal vessel a little distance away from the disc He then finds the highest convex glass with which he can see a vessel or a small hæmorrhage as near the top of the swollen disc as he can judge The

difference between the two lenses will give the height of the swelling

It will be seen that the difficulty of relaxing the accommodation enters into this estimation   The student need not, however, be dismayed   Very fairly accurate results can be obtained without relaxing the accommodation, for if he is accommodating the same amount when he measures the top of the swelling that he is when he measures the level of the surrounding fundus the difference between the two observations will be the same as if he was not accommodating at all. He can ensure this fairly well by always choosing the highest convex lens, it is safest to choose the lens which just makes the object looked at appear a little blurred   Of course, the eye may be myopic, if for "convex lens" in the above description "relatively convex lens" be substituted (— 1 D being relatively convex to — 4 D) the principle is the same

An object in the vitreous, e g , a large opacity, is in the same condition as the fundus of a hypermetropic eye   If the eye is emmetropic, so that the fundus is visible without any correcting lens, the opacity can be examined either by accommodating for it or by putting up convex lenses until it is clearly focussed   If it is close behind the lens, accommodation will have to be assisted by a convex lens in any case, unless the observer withdraws farther from the eye   It will be seen, therefore, that by putting up convex lenses from 0 to + 20 D we can thoroughly explore the emmetropic eye from the fundus to the surface of the cornea.

Examined in this manner the appearance of opacities in the vitreous or lens will vary with the amount of light stopped by them, i.e , by their density, and with the amount of light reflected from their surfaces   If these are very dense they will appear black against the background of the red reflex   If they are semi transparent they will appear red or whitish according to the relative amounts of light transmitted from the fundus and reflected from the surface. A detached retina may there fore look red or white, according to its degree of transparence   If much light is reflected from the surface details may be seen upon it , otherwise it appears uniformly black.

CHAPTER VIII

The Fundus Oculi

WHEN the fundus is observed by the indirect method it is seen to be of a bright red colour   This is due chiefly to the blood circulating in the choroid   In people of dark complexion no choroidal blood vessels are seen on account of the retinal pigment epithelium, which, while dense enough to blur any details, is not sufficiently so to prevent the colour of the blood manifesting itself

The Optic Disc   The first object to be sought is the optic disc or papilla (Plate III, Fig 1)   As already mentioned, it is done by making the patient look slightly towards the nasal side   The reflex then suddenly changes from bright red to pale red, and if the optical conditions are properly arranged in accordance with the directions given in the last chapter the disc will be clearly seen

The disc is pale pink in colour, the tint showing considerable variations within the limits of normality   It is nearly circular but seldom perfectly so, it is about 1 5 mm in diameter, but of course is seen magnified   The oval appearance due to astigmatism must be borne in mind (vide p 120)   The edges are usually quite sharp, but sometimes a little irregular   Not uncommonly, especially in old people, there is a narrow white ring around the pink disc, the *scleral ring*, this is due to the choroid and the pigment epithelium of the retina not extending quite up to the margin of the disc so that the sclerotic is seen through the retina   Sometimes there is a ring of black pigment around the margin of the disc, due to the retinal pigment epithelium being heaped up here   More commonly parts of the circumference have black patches, but they are not continuous   These features are of no importance from the pathological point of view

The disc itself is seldom uniformly pink   The central part is usually paler and may be quite white, and this lighter area may extend nearly to the temporal edge of the disc, it rarely extends quite to the edge   The temporal side is therefore normally paler than the nasal   The central vessels emerge

from the middle of this white area and careful examination with the direct method will show that the area is a funnel shaped depression, the *physiological cup*. This cup varies very much in different eyes. When it is very deep the central part may be seen to be speckled with grey spots, these are the meshes of the lamina cribrosa through which the nerve fibres are passing. Sometimes there is scarcely any physiological cup, the disc is then more uniformly pink and the central vessels may have already divided before they come to the surface. The true nature of the physiological cup is best understood by comparing the ophthalmoscopic picture with a microscopic section vertically through the nerve head.

The colour of the disc is due to the white fibres of the lamina cribrosa seen through the vascularised nerve fibres. Where the nerve fibres are thinnest i.e., in the cup, the white lamina shines through brightest. The grey spots in the lamina, when they are seen are due to the non medullated nerve fibres reflecting less light than the white connective tissue fibres.

The Retinal Vessels. The retinal vessels are derived from the central artery and vein which usually divide into two branches at or near the surface of the disc. These branches are above and below and form a superior and an inferior trunk (Plate I). Each trunk usually divides into two one of which sweeps up or down towards the temporal side, the other sweeping up or down towards the nasal side. These branches are called the superior and inferior temporal and nasal arteries and veins. They divide dichotomously into innumerable branches.

The arteries are distinguished from the veins in being lighter red and narrower. The veins have a purplish tint and are often more convoluted less frequently the arteries are tortuous. What is seen is the blood column not the actual vessel wall which is transparent. Each but especially the arteries may have a bright silvery streak running longitudinally down the centre due to reflection of light from the convex cylindrical surface.

The mode of branching of the vessels is subject to great variation though it is derived from the fundamental type described. The variations are generally of no practical importance. The primary division of the superior and inferior trunks usually takes place on or very near the disc. The nasal branches run much more radially than the temporal which make a very decided sweep to avoid the macula.
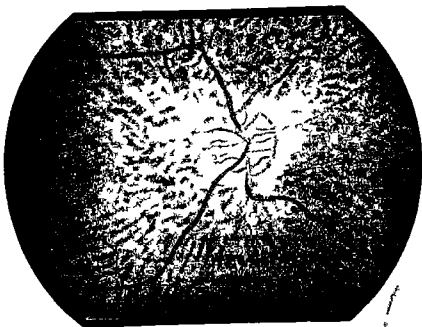
PLATE III

Fig. 1. Normal fundus.

Fig. 2. Normal fundus, stereoscopic variety.

PLATE IV
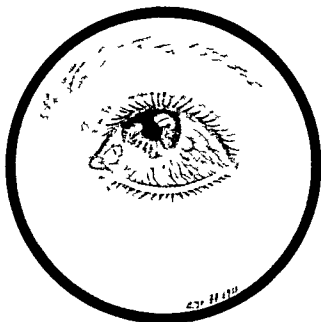
Fig. 1.—Phlyctenular conjunctivitis
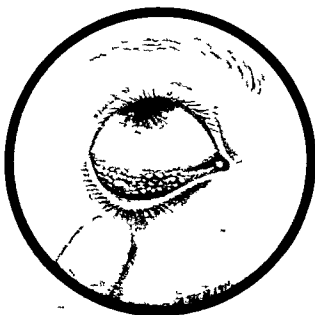
Fig. 2.—Follicular conjunctivitis

The Macula lutea is situated about 3 mm or 2 disc diameters (2 p d) to the temporal side of the edge of the disc, and is a little below the level of the horizontal merid an   It is very difficult to see without a mydriatic, for the bright light on this most sensitive spot causes maximal constriction of the pupil the corneal reflex then usually obliterates all view   It may generally be seen by using very dim illumination

The macula varies in appearance according to illumination, refraction, complexion, &c   In general, it is a small circular area of a deeper red than the surrounding fundus, sometimes looking almost black   There is nearly always a *foveal reflex*, due to reflection of light from the walls of the foveal depression   This is most frequently seen as a silvery ring of light hiding every thing behind it   it may be circular or oval, according to the incidence of the light and the refraction of the eye   Often there is an intensely bright spot at or close to the fovea, also due to re flection   The deeper red of the macula is due to the thinness of the retina, so that the specially vascular chorio capillaris of this region is seen more clearly   shadows thrown by the edges of the foveal depression may contri bute a share to the deepening of the colour

The macular region is supplied by twigs from the superior and inferior temporal arteries, and by small branches coming straight from the disc   There are no retinal blood vessels actually at the fovea (Fig 5), and none can be seen ophthalmoscopically for a little distance around   Occasionally there are small arteries (cilio retinal) derived from the ciliary system   They start near the edge of the disc, run inwards, and then bend sharply outwards towards the macula (Fig 91)

Fig 91 —A cilio retinal artery

The General Fundus   The appearance of the general fundus varies enormously within healthy limits   It is especi ally determined by the complexion of the patient, which may be taken as an index of pigmentation in different parts of the body   In people who are neither very dark nor very light the spaces between the retinal vessels show a uniform redness, occasionally with a very delicate punctate stippling, e

towards the periphery   In albinos the choroidal vessels are
seen clearly, the spaces between them being white, due to the
sclerotic shining through   In partial albinism the macular
region usually shows a uniform normal redness, the lack of
pigmentation being manifested peripherally   Subjects of this
condition are generally found to have had very light hair as
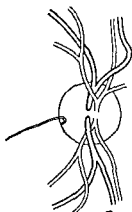infants   In very dark people the fundus is a darker red, and
indications of the choroidal vessels are often seen as indefinite
brighter red streaks   Sometimes the pigment between the
choroidal vessels is particularly dense, or the pigment is
deficient in the retinal pigment epithelium, while the choroid
is deeply pigmented   the choroidal vessels are then seen
separated by deeply pigmented polygonal areas (*tigroid* or
tesselated fundus) (Plate III   Fig 2)

There is no difficulty in distinguishing the choroidal from
the retinal vessels when both are visible (*cf* Plate X , Fig 2)
The former are broader and ribbon like, without any central
reflex streak   they anastomose freely, unlike the retinal
vessels, which do not anastomose at all   Moreover, in certain
parts, their anatomical distribution is very characteristic (*vide*
p 11)

All the details of the fundus will be seen much better by the
direct method, unless the eye is very myopic, when the magni-
fication is so great and the area seen is so small that it is
difficult to find any particular spot

Under normal conditions no pulsation can be seen in the
retinal arteries   The retinal veins, however, may often be
seen to pulsate at or near the edge of the disc, or indeed
wherever they take a very sharp bend   This is usually due to
transmitted pressure   The blood pressure is lowest in the
veins near the disc, and there is a certain amount of obstruc-
tion to the flow of blood as the vessels pass through the narrow
neck at the lamina cribrosa   With each arterial pulsation the
intraocular pressure is suddenly raised slightly, so that the
pressure on the outside of the walls of the veins is increased
This causes a sudden increased obstruction to the outflow of
blood from the eye , the wall of the vein becomes slightly
compressed, recovering itself during the arterial diastole
Hence pulsation is observed, and it will be seen best where
the intravenous pressure is least, viz , nearest the heart, i e ,
at the disc, and where there is any additional obstruction, viz ,
near the lamina cribrosa and at any sharp bend   The venous
pulsation can be increased or made manifest if absent by slight
pressure on the globe, which has the effect of increasing the

intraocular pressure This normal venous pulse is seen with
out the artificial aid of pressure on the globe in 70 to 80 per
cent of people It will be noticed that it is diastolic, it has
therefore been called the *negative venous pulse*

Two other forms of venous pulse occur in pathological
conditions

The *positive venous pulse* is presystolic, continuing into the
systolic phase it is due to tricuspid regurgitation, and is per
mitted by the normal insufficiency or absence of valves in the
jugular veins The *transmitted centripetal venous pulse* is an
accentuation of the normal tendency of the pulse wave to pro
gress through the capillaries into the veins, owing to the intra
ocular tension It is due to venous congestion, with or without
increased *vis a tergo*

Visible arterial pulsation is always pathological The blood
pressure in the ophthalmic artery is only a few mm Hg
below that of the carotid in animals (vide p 16) Considering
the differences of blood supply it would be unwise to apply the
result directly to man, but there is no doubt that the pressure
in the central artery is far above the intraocular pressure It
would not be surprising, therefore, if the pulse wave were
transmitted and could be seen There are two reasons which
militate against this (1) the intraocular pressure damps the
pulsation, and the increase in pressure which accompanies
each pulsation is spread over the whole volume of the contents
of the globe, and is transmitted to the plastic sclerotic, (2) such
pulsations as survive this damping effect are too slight to be
observed in such small vessels by ordinary ophthalmoscopic
examination

Two types of arterial pulsation occur pathologically (1) a true
pulse wave, accompanied by locomotion of the vessels, (2) an
intermittent flow of blood, or pressure pulse In the latter the
arteries fill only with the heart beats, being empty between them
it is only visible on the disc, and may be produced in a normal
eye by external pressure upon the globe by a finger applied to
the lid This type of pulsation is a pure pressure phenomenon,
and is caused by any considerable increase of intraocular tension
with normal or lowered blood pressure, e g, in glaucoma, or by
any considerable diminution of blood pressure with normal
intraocular pressure, e g, in syncope, orbital tumours, &c The
true arterial pulse occurs in cases of aortic regurgitation or
aneurysm, in exophthalmic goitre, &c, it is not confined to the

disc It is equally a pressure phenomenon, but the differences of pressure are smaller

Capillary pulsation is seen only in aortic regurgitation as a systolic reddening and diastolic paling of the disc

The order of examination of the details of the fundus should be systematic Applying the indirect method we obtain a general view The patient is instructed to fix the gaze in such a direction that the disc is brought into view It will occupy about the centre of the field, and a considerable area around will be visible Any gross abnormality is detected at once The shape and colour of the disc, the arrangement of the vessels the colour of the choroidal reflex (its uniformity or tesselation), gross abnormalities (white or pigmented spots, &c), are readily noted The patient is then directed to look up to the ceiling, to the right, to the left, and down to the ground , in the latter position the upper lid is gently raised by a finger of the hand which is holding the large lens, as otherwise it will cover the pupillary area In this manner the periphery of the fundus is brought into view Even when the central parts of the fundus are uniformly tinted the periphery often displays traces of the choroidal vessels, associated with greater pigmentary stippling or a diminution of pigment Only minute investigation with the direct method can show whether this is normal or pathological The characteristic type and distribution of the pigmentation of retinitis pigmentosa is best demonstrated in this manner

Having thus obtained a good general idea, the systematic examination is repeated by the direct method, paying special attention to points which the indirect method has left uncertain The details of the disc—physiological or pathological cupping, blurring of the edges or swelling, abnormalities of the edges in the form of crescents and so on—are inspected Attention is then turned to the vessels Abnormalities in arrangement or distribution, the presence of cilio retinal vessels &c , are noted The details of the individual vessels—their relative size, irregularity of contour or varicosity, visibility of the walls as shown by the presence of white lines along the edges, abnormalities of the reflex streak, &c —are investigated The vessels are traced towards the periphery and the smaller vessels inspected Changes often occur near the vessels, such as small hæmorrhages, white spots of exudate, &c , these are carefully looked for

Next the macula is examined this should never be omitted

It may be brought into view by telling the patient to look into the light, with unintelligent patients it is best to say nothing, but fix the temporal edge of the disc and pass horizontally outwards for a distance of about two papilla diameters (a convenient unit in ophthalmoscopic topography), when the macula will be found. If the patient is not under a mydriatic or the pupil movements are not abolished by disease (optic atrophy, &c.) the light should be lowered so that the constriction of the pupil may be reduced to a minimum. The corneal reflex is always troublesome, but has to be dodged. Any abnormality at or near the macula is of the utmost importance. Black or white spots are often very difficult to distinguish from shadows or reflexes. if either can be made out by any means (e.g., the use of a concave lens) to have a definite sharp contour, and if they do not seem to shift in the slightest degree when a minute movement is made with the mirror, it may be concluded that they are pathological entities.

Finally, the periphery of the fundus is investigated. It is important to know how far out we can see by the direct method. With modern ophthalmoscopes and full dilatation of the pupil it is possible to see almost to the ora serrata, especially if the sclera is slightly indented with a squint hook. The periphery, even in an emmetropic eye, is usually best seen with a low convex lens, owing to the obliquity of the axis of the rays as they pass through the crystalline lens.

CHAPTER IX

Functional Examination

In the second great group (*vide* p 79) of ophthalmic patients there are no manifest objective signs of disease, and we are dependent at the outset upon the subjective symptoms of which the patient complains In these cases, after a rapid, but careful, external examination to eliminate any objective sign which may have escaped observation, it is usually most convenient to proceed at once to the functional or subjective examination Whether this produces evidence of abnormality or not, it is imperative to proceed then to the systematic internal examination with the ophthalmoscope

On the other hand, in the first group of ophthalmic patients, in spite of external signs of disease which may suffice to account for the symptoms, it is the surgeon's duty to eliminate as far as possible all other evidence of abnormality Ophthalmoscopic examination may be impossible at the first visit, and subjective functional testing may be so vitiated by the obvious disease as to afford no useful information In such cases functional and internal examination should be postponed until a future visit, but in no case should it be entirely omitted It should be borne in mind that, rightly or wrongly, the surgeon is liable to be held responsible for the discovery of any disorder of the eye which manifests itself at or about the time of his examination

The functional examination of the eye proper consists in testing the acuity of the forms of visual perception which have been already mentioned, viz , the light sense, the colour sense, and the sense of form They are usually tested in the reverse order Each eye must be tested separately through out In the preliminary examination it is sufficient to test first the acuity of central vision for distant and for near points, then roughly the field of vision, and finally the reactions of the pupils, afterwards proceeding forthwith to the ophthalmoscopic examination It may then be necessary to revise the rough test of the field of vision by mapping it out with greater precision, to supplement the tests with white light by those

with coloured objects, both in the central and peripheral parts of the field and to estimate, more or less accurately, the light minimum and the light difference In the routine examination it is well to test roughly the condition of the extrinsic muscles before proceeding to the ophthalmoscopic examination (Section V)

The Acuity of Vision The acuity of distant central vision is now almost invariably tested by means of Snellen's Test Types (Fig 92) These are constructed upon the fundamental principle that the average minimum visual angle is 1 minute

The types consist of a series of letters diminishing in size The breadth of the lines of which the letters are composed is such that the edges subtend an angle of 1 minute at the nodal point of the eye Each letter is of such a shape that it can be placed in a square, the sides of which are five times the breadth of the constituent lines (Fig 92) Hence the whole letter will subtend an angle of 5 minutes at the nodal point of the eye (Fig 93)

In order that these conditions may be fulfilled it is obvious that such a letter to be used as a test a long distance from the eye must be larger, and the constituent lines must be broader than in the case of a letter to be used nearer the eye In Snellen's types the largest letter will subtend 5 minutes at the nodal

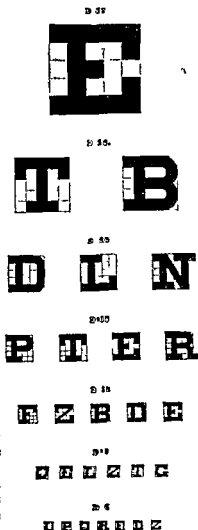

Fig 92 —Snellen's Distant Test Types (reduced) The lines from above downwards should be read at 60 metres 36 metres 24 metres 18 metres 12 metres 9 metres and 6 metres respectively i e, at these distances the letters subtend a visual angle of 5

point if it is 60 metres from the eye Those in the second
line will subtend 5 minutes if they are 36 metres from the eye,
those of the consecutive lines 24 metres, 18 metres, 12 metres,
9 metres, and 6 metres Sometimes smaller letters correspond
ing to 5 metres 4 metres, 3 5 metres are used

A person with average acuity of vision ought therefore to
be able to read the top letter at 60 metres, the second line at
36 metres, the third at 24 metres, and so on Now, it would
be very inconvenient to have to alter the distance between
the patient and the letters to this large extent A numerical
convention which gives a fair comparative estimate of the
value of different acuities of vision has therefore been adopted

The patient is kept at a fixed distance from the types This
distance should never be less than 5 metres, or preferably
6 metres At such a distance the divergence of the rays in
the small bundle which enters the pupil is so slight that it
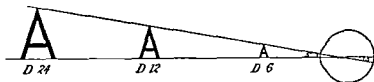
FIG 93

can be neglected the rays being considered parallel If the
distance were 3 metres, for example, an appreciable amount
of accommodation would have to be exerted by an emmetrope
eye in order to bring the rays to a focus upon the retina
hence the estimate of distant vision would be fallacious

A normal patient 6 metres from the types ought to be able
to read every letter from the top to the end of the 6 metre
line, many people can read more in a good light Suppose
the patient can only read the 18 metre line His distant
vision is obviously defective The numerical convention
which is used to record this is a fraction in which the numerator
is the distance at which he is from the types, and the denomina
tor is the distance at which a person with normal vision ought
to be able to read the last line which he succeeds in reading
The patient under consideration will therefore have his distant

vision recorded thus $V = \dfrac{6}{18}$ The normal patient's vision

will be $V = \dfrac{6}{6}$

These fractions give an indication that the normal patient's vision is unity, whilst the other patient's is one third as good. The fraction should not be reduced in this manner, because it is only an accurate numerical estimate under special conditions It should be used merely as a convention, just as *numbers are used to indicate variations in tension* If the fraction is reduced much valuable information is lost In its original form it indicates the actual types used and the actual distance away from the types , it therefore eliminates doubt as to the accuracy of the application of the test

The *amount of illumination on the test card* has a considerable influence on normal visual acuity It has been found that the acuity rises rapidly as the illumination is increased from zero up to 2—3 ft candles above 2—3 ft candles the rise is slight The illumination of the test card should never be allowed to fall below 5 ft candles, and it would be advantageous if the standard illumination recommended by the Council of British Ophthalmologists were universally adopted

If the patient cannot read the largest letter he is told to walk slowly towards the types At a certain distance he may be able to see the top letter He should then be moved back a little, since he may not have understood exactly where to look In this manner the farthest point at which he can distinguish the top letter is determined If this is 3 metres, the vision is recorded thus—V = 3/60 Perhaps he is unable to see the top letter even close to it In that case he is asked to count the extended fingers of the surgeon's hand, held up at about 1 metre against a dark background the distance is varied to obtain about the maximum This is recorded thus—V = fingers at 1 metre If he cannot count fingers he is told to look at the light, either artificial or the window , the surgeon's hand is then moved between the eye and the light If he can distinguish the movements of the hand it is recorded as V = hand movements If he is unable to distinguish hand movements he is taken into the dark room and the light is alternately switched on and off, or light is concentrated on his eye with a convex lens or with the ophthalmoscope mirror, and he is asked to say when the light is on the eye and when it is off If he succeeds in doing this, V = p l (perception of light) If he fails to see the light at all the vision is recorded as V = no p l

It does not follow that a patient who reads 6/6 is emmetropic he cannot be myopic unless he is screwing up his

eyes, and in any case he cannot be very myopic   He may,
however, be hypermetropic, for by an effort of accommodation
he can bring the practically parallel rays emitted by the
letters to a focus on his retina   We wish, then, to find out
if he is accommodating   It is done by finding out the highest
convex lens, placed before his eye in a testing spectacle frame,
with which he can still read 6/6

Directly a convex lens is placed before the eye in a patient
who has good accommodative power it tends to make objects
look blurred   Hence it is best to start with a convex lens
which will quite definitely blur the types and then gradually
counteract it by placing concave lenses of increasing strength
in contact with it   A + 4 D lens is put in front of the eye.
Probably the patient now reads only a few lines   With the
+ 4 D still in position a — 0 5 D is put in front of it , the
patient perhaps reads another line   The — 0 5 D is replaced
by a — 1 D , he still fails to read 6/6   The — 1 D is replaced
by — 1 5 D , we will suppose that he now reads 6/6   This
proves that he has average normal vision with a + 2 5 D lens
With the assistance, therefore, of a 2 5 D convex lens he can
relax his accommodation the corresponding amount   It by
no means follows that this represents the total amount of his
hypermetropia   As has already been pointed out (*vide* p 52),
the younger the person the greater the capacity to accommo-
date   Young people, therefore, have great facility in accom
modating   If they are hypermetropic this fund has been
drawn upon for a long period, so that a condition of partial
contraction of the ciliary muscle becomes normal to them
Sometimes even there is excessive contraction of the muscle,
so that they become artificially myopic, a condition which is
called " spasm of accommodation " , it is probably diagnosed
more often than it occurs

The younger the patient, therefore, the easier it will be for
him to accommodate and the more difficult to relax his accom-
modation completely   That part which he can relax when
convex lenses are used as described above is called his *manifest
hypermetropia* (Hm)   The part which he is unable to relax,
which can only be determined by paralysing the ciliary muscle,
is called his *latent hypermetropia* (Hl)   The sum of the mani
fest and latent hypermetropia is called the *total hypermetropia*
In extreme youth nearly all the hypermetropia is latent the
lens is so resilient that it is impossible to prevent it responding
to the slightest stimulus   As the lens becomes less plastic
more and more of the hypermetropia becomes manifest, until,

finally, when accommodation disappears entirely, all the hypermetropia is manifest   The older the patient, therefore, the nearer the manifest hypermetropia represents the total amount

The vision of the patient in the above example is usually recorded thus $V = \dfrac{6}{6}$, Hm + 2 5

With intelligent patients who do their best to read as many letters as possible without continual encouragement from the surgeon the manifest hypermetropia is obtained with less trouble by simply putting up convex lenses of gradually increasing strength until the last line which can be read becomes blurred

An older patient than the one considered in the previous example will very likely read more with a convex glass than without it   Thus a patient of fifty five may perhaps read only 6/12, while with a + 2 D he reads 6/6   This man has a manifest hypermetropia of 2 D   Since he is fifty five years of age he has only 1 D of accommodation left (*vide* p 54) When he reads with the unaided eye he uses up this 1 D in getting as far as 6/12 , he is unable to accommodate any more, so the lower letters are too blurred to read   He may manage to read 6/6 with the assistance of a + 1 D, since this, with the remnant of his accommodation, will fully correct his hypermetropia   On seeking the highest convex glass we find he can read 6/6 as well or better with + 2 D   This, therefore, represents his manifest hypermetropia   Such a case is recorded thus $V = \dfrac{6}{12}$ Hm $+ 2 = \dfrac{6}{6}$

Apart from counteracting a convex lens as described above the student should not use concave lenses in testing the distant vision, unless the patient is under a mydriatic   An emmetrope, or even a hypermetrope, if neither is presbyopic, will read 6/6 quite well with weak concave lenses *in front of the eye* , he simply accommodates the amount which is *requisite to counteract the lens*   Hence, unless the patient is under the influence of a mydriatic, we learn nothing from the procedure , it is therefore redundant

Having tested the distant vision and determined the amount, if any, of the manifest hypermetropia, the near vision should next be tested   For this purpose test types for near vision are used (Fig 94)   Snellen's are constructed on exactly the same principle as the distant ones and are therefore theore-

eyes, and in any case he cannot be very myopic   He may, however, also be hypermetropic, for by an effort of accommodation he can bring the practically parallel rays emitted by the letters to a focus on his retina   We wish, then, to find out if he is accommodating   It is done by finding out the highest convex lens, placed before his eye in a testing spectacle frame, with which he can still read 6/6

Directly a convex lens is placed before the eye in a patient who has good accommodative power it tends to make objects look blurred   Hence it is best to start with a convex lens which will quite definitely blur the types, and then gradually counteract it by placing concave lenses of increasing strength in contact with it   A + 4 D lens is put in front of the eye. Probably the patient now reads only a few lines   With the + 4 D still in position a — 0 5 D is put in front of it, the patient perhaps reads another line   The — 0 5 D is replaced by a — 1 D, he still fails to read 6/6   The — 1 D is replaced by — 1 5 D, we will suppose that he now reads 6/6   This proves that he has average normal vision with a + 2 5 D lens   With the assistance, therefore, of a 2 5 D convex lens he can relax his accommodation the corresponding amount   It by no means follows that this represents the total amount of his hypermetropia   As has already been pointed out (*vide* p 52), the younger the person the greater the capacity to accommodate   Young people, therefore, have great facility in accommodating   If they are hypermetropic this fund has been drawn upon for a long period, so that a condition of partial contraction of the ciliary muscle becomes normal to them   Sometimes even there is excessive contraction of the muscle, so that they become artificially myopic, a condition which is called "spasm of accommodation", it is probably diagnosed more often than it occurs

The younger the patient, therefore, the easier it will be for him to accommodate, and the more difficult to relax his accommodation completely   That part which he can relax when convex lenses are used as described above is called his *manifest hypermetropia* (Hm)   The part which he is unable to relax, which can only be determined by paralysing the ciliary muscle, is called his *latent hypermetropia* (Hl)   The sum of the manifest and latent hypermetropia is called the *total hypermetropia*   In extreme youth nearly all the hypermetropia is latent   the lens is so resilient that it is impossible to prevent its responding to the slightest stimulus   As the lens becomes less plastic more and more of the hypermetropia becomes manifest, until,

finally, when accommodation disappears entirely, all the hypermetropia is manifest. The older the patient, therefore, the nearer the manifest hypermetropia represents the total amount

The vision of the patient in the above example is usually recorded thus $V = \frac{6}{6}$, Hm $+ 2\ 5$

With intelligent patients who do their best to read as many letters as possible without continual encouragement from the surgeon, the manifest hypermetropia is obtained with less trouble by simply putting up convex lenses of gradually increasing strength until the last line which can be read becomes blurred

An older patient than the one considered in the previous example will very likely read more with a convex glass than without it. Thus a patient of fifty five may perhaps read only 6/12, while with a + 2 D he reads 6/6. This man has a manifest hypermetropia of 2 D. Since he is fifty five years of age he has only 1 D of accommodation left (*vide* p 54) When he reads with the unaided eye he uses up this 1 D in getting as far as 6/12, he is unable to accommodate any more, so the lower letters are too blurred to read. He may manage to read 6/6 with the assistance of a + 1 D, since this, with the remnant of his accommodation, will fully correct his hypermetropia. On seeking the highest convex glass we find he can read 6/6 as well or better with + 2 D. This, therefore, represents his manifest hypermetropia. Such a case is recorded thus $V = \frac{6}{12}$ Hm $+2 = \frac{6}{6}$

Apart from counteracting a convex lens as described above the student should not use concave lenses in testing the distant vision, unless the patient is under a mydriatic. An emmetrope or even a hypermetrope, if neither is presbyopic will read 6/6 quite well with weak concave lenses in front of the eye, he simply accommodates the amount which is requisite to counteract the lens. Hence, unless the patient is under the influence of a mydriatic, we learn nothing from the procedure, it is therefore redundant

Having tested the distant vision and determined the amount, if any, of the manifest hypermetropia, the near vision should next be tested. For this purpose test types for near vision are used (Fig 94). Snellen's are constructed on exactly the same principle as the distant ones and are therefore

tically more accurate   The legibility of small types has been found empirically to be increased by slight modifications in the breadths and forms of the letters (*vide* p 685)   Ordinary types in common use are therefore more legible than Snellen's types of corresponding size   Jaeger's near test types which are very frequently used, are simply the ordinary printer's founts of type, from the smallest upwards (nonpareil, minion, &c)   They are sufficiently accurate for practical purposes

The patient is told to hold the test card   The position where he holds it of his own accord will often impart useful information   If he is old and holds it a long distance away, he is most likely to be an emmetropic or hypermetropic presbyope   If he holds it closer than the ordinary reading distance and reads the smallest type fluently, he is probably myopic, whatever his age may be, though children often get into the habit of holding books unnecessarily close

Take first the example of an emmetrope   We find that he reads 6/6, that he has no manifest hypermetropia and that he reads Jaeger 1, holding it of his own accord at ordinary reading distance (22 cm or 9″)   This is recorded—V = 6/6 no Hm , J 1   If no distance is stated in recording the near vision it is understood to be the normal distance

Take now a patient who reads only 6/60, has no manifest hypermetropia, but reads Jaeger 1 fluently, only, however, when the card is held closer than normal to the eye   In this case the distance at which the card is held should be guessed or measured   Let us suppose that it is about 5 inches   This is recorded—V = 6/60 no Hm , J 1 at 5″

Take now a patient of fifty five who reads 6/6, and has no manifest hypermetropia   We give him the near types, and he holds the card a long distance off, but even so cannot read Jaeger 1   In this case it is waste of time to discover exactly which type he can read, and to measure the distance at which he can read it   We know that as he is fifty five he has only 1 D of accommodation remaining (*vide* p 54)   What we wish to know is whether he can read Jaeger 1 at ordinary reading distance if we correct his presbyopic defect   We therefore at once put up a + 3 D lens before his eye   tell him to hold the types closer, and ask him if he can read the smallest   He will probably do so easily   This is recorded—V = 6/6, no Hm , c + 3 = J 1

Finally, take a patient of fifty who reads 6/12, but with + 2 D reads 6/6   He will hold the near types a long distance away as in the last example   if we investigate the question he

J 1 (Sn. 05)   50 cm

As she spoke, Moses came slowly on foot and seemed quite under the deal box which he had slung round his shoulders like a pedlar "Welcome, welcome Moses wh‌at, my boy what have you brought us from the fair" "I have brought you myself" cried Moses, with a sly look and setting the box on the counter "Ay Moses," cried my wife, "that we

J. 2 (Sn. 06)   60 cm

five shillings and twopence is no bad days work Come let us have it then."—"I have brought back no money" cried Moses again I have laid it all out in a bargain, and here it is" pulling out a bundle from his breast here they are a gross of green spectacles, with silver rims and

J 4 (Sn. 10)   80 cm

mother cried the boy why won't you listen to reason" I had them a dead bargain or I should not have brought them. The silver rims alone will sell for double the money — A fig for the silver rims cried my wife in a passion I dare

J. 6 (Sn 1)   1 m.

the rims for they are not worth sixpence, for I perceive they are only copper varnished over'—'What!'' cried my wife, ' not silver! the rims not silver? —'No,' cried I, no more silver

J. 8 (Sn 125)   1.25 m

with copper rims and shagreen cases? A murrain take such trumpery! The blockhead has been imposed upon, and should have known his company better"—"There,

J 10 (Sn 15)   15 m.

the idiot!" returned she, " to bring me such stuff if I had them I would throw them in the fire"— "There again you are wrong, my dear," cried I,

J 12 (Sn 175)   175 m

By this time the unfortunate Moses was undeceived He now saw that he had

J. 14 (Sn 225)   225 m

asked the circumstances of his deception. He sold the horse, it

FIG 94 —TEST TYPES FOR NEAR VISION

Jaeger Test Types, with approximate Snellen equivalents and the most remote distances at which each should be read with average normal vision

will not be able to read nearly as well even a long distance away as the last patient He has only 2 D of his accommodation

remaining, but he also has 2 D of hypermetropia   We cannot therefore expect him to read Jaeger 1 at ordinary reading distance unless we not only correct his presbyopia but also his hypermetropia   We therefore at once put up a + 4 D, and find that he reads Jaeger 1 at ordinary distance quite well   This is recorded—V = 6/12   Hm + 2 = 6/6, ♂ + 4 = J. 1

The ordinary rule of presbyopic loss of accommodation, viz., 1 D for each five years after forty, is a liberal allowance, and we often find that patients are more comfortable with less (*vide* p 54)   The lower correction should be ordered and only in very exceptional cases should more be ordered

An indication of the *range of accommodation* is given by the knowledge of the manifest hypermetropia, combined with the ability to read the small types at ordinary reading distance   Strictly, the accommodation should be more carefully tested in each case, but this is often neglected

The method adopted to find the near point of the eye has already been mentioned (*vide* p 50)   For practical purposes it is sufficient to use the smallest Jaeger or Snellen near type and approach it nearer and nearer to the eye until it can no longer be read   The last point at which it can be read gives the near point   The distance of the near point from the eye is then measured with a tape   This distance is transformed, if necessary, into millimetres (25 mm = 1 inch), and the range of accommodation is deduced from the formula A = P—R (*vide* p 52)   Of course, the full range of accommodation in a hypermetrope cannot be accurately arrived at unless the total hypermetropia is known, this may require the use of a mydriatic   Practically, however, we are chiefly concerned in discovering paralysis or paresis of accommodation such as may occur after diphtheria or previous use of a mydriatic   In these cases the knowledge of the distance of the near point is sufficient

The next step—one which is far too often neglected—is in every case to test the *pupil reactions* and record them   If the visual tests have shown deficiency it may be necessary to use a mydriatic, in which case it will be impossible to test the pupil reactions at a later stage of the same visit   hence the import ance of recording them at once

We should also test the field of vision roughly

The Field of Vision —There are several methods of testing the field of vision

(1) A rough, but very useful, method, the so called con

frontation test, which should be applied in every case, at any rate if there is the slightest suspicion of defect, is as follows :—

The surgeon stands facing the patient at a distance of about 2 feet The patient covers his left eye with the palm of his hand He is told to look straight into the surgeon's left eye The surgeon closes his right eye He then moves his hand in from the periphery towards the common line of vision of the patient's right and his own left eye, keeping his hand in the plane half way between the patient and himself Directly he sees it himself the patient ought to say that he also sees it The movements of the hand are repeated in various parts of the field—above, below, to the right, to the left, and so on

This method is extremely simple, rapidly applied, and an excellent test It will be seen that the surgeon tests the range of the patient's field by that of his own, which may be considered normal , moreover, he is continually watching the patient's eye, so that he can at once observe any deflection from the point of fixation

The gross defects in the field which are most likely to escape recognition are homonymous and bitemporal hemianopia, the latter usually due to acromegaly or tumour of the pituitary body (Chap XIX) They may be roughly tested for by telling the patient to look straight at the surgeon, situated as before, both eyes being open The surgeon holds up both hands, one in each temporal field, and the patient is told to touch the surgeon's hand If he asks " Which one ? " he has not bitemporal hemianopia, since he sees both hands. If he promptly points to one hand he should be asked if he sees the other , if he does not, he probably has homonymous hemianopia

If any defect is indicated by these methods or is suspected from other features of the case it must be accurately mapped out and recorded with the perimeter

(2) *The Perimeter*—The perimeter consists essentially of an arc, marked on the back in degrees of a circle, capable of being revolved round a pivot which the patient fixes with the eye under examination (Fig 93) The chart, which has concentric circles marked upon it, corresponding with the degrees on the arc, is under the surgeon's control at the back of the perimeter In self registering perimeters, which are almost invariably used, the readings are recorded by perforations with a sharp point

The details of taking a perimetric chart can only be taught

by actual demonstration. It will suffice to emphasise here the chief procedures to be followed in order that accuracy may be attained

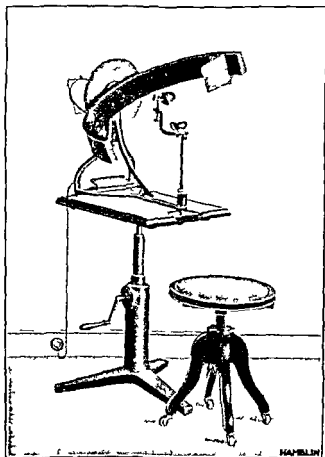The patient is seated with his back to the light   His chin

Fig 95—Lister perimeter and scotometer

rests upon the chin rest, the face is vertical and not tilted to one side, one eye is covered   The other eye, situated at the centre of the arc, fixes the white dot around which the arc revolves

The field should first be taken with a white object 10 mm in diameter   At least eight meridians must be investigated,

preferably sixteen If the field is very small a 5 mm square should be substituted, and the process repeated In each meridian the object should be carried quite up to the fixation point, as there may be areas inside the limits of the field which are blind (*absolute scotomata*) These should be mapped out with the same accuracy as the extreme limits of the field If the scotomata are small the limits may be determined with an intelligent patient best with a very small object, *e g*, 2 mm square The size of the test object and the distance from the perimeter may be conveniently recorded by a convention similar to the mode of recording visual acuity, *e g*, 10/300, both distances being expressed in millimetres (A H H Sinclair) With small objects *relative scotomata* can be found which are not demonstrable with large objects

Having mapped out the field for white the process should be repeated with similar, but coloured, objects The limit of the field for a colour is the point at which, passing from the periphery to the centre the colour first becomes evident Peripheral to this limit the object may still be perceptible but appears grey The exact limit is difficult to determine, for most colours change in hue and saturation as the object passes from the fixation point towards the periphery Red or green should be used first, then blue or yellow Under ordinary circumstances, the blue field is largest, slightly smaller than the white then follow the yellow, red and green in the order named (Fig 96). There is a particular purplish red and a particular bluish green (490 $\mu\mu$) which have the same field, and similarly a particular blue (460 $\mu\mu$) and a particular yellow (570 $\mu\mu$) These pairs of colours are complementary, *i e*, a mixture of the red and the green, or of the blue and the yellow, produces white

The extent of the normal field, with a 10 mm square, under good illumination, is shown in the accompanying chart (Fig 96) The peculiar shape is essentially due to the shape of the sensitive area of the retina as projected outwards, but is often modified when the field is taken in the ordinary manner by interference caused by the nose and the brows, this complication can be eliminated if, when the field of the right eye is being taken, the head is turned somewhat to the left, and *vice versa* It is seen that the field for white extends upwards 45°, outwards rather more than 90°, downwards 70°, and inwards 60° The size varies with the illumination, the size of the test object, the contrast of the test object with the background, and the state of adaptation of the eye The field for

blue and yellow is roughly 10° less in each direction, that for red and green another 10° less   The limits of the colour fields vary not only with the intensity of the light, but also with the saturation of the colour, and above all with the size of the object   If these are sufficiently great, colours may be recognised almost, if not quite, at the periphery

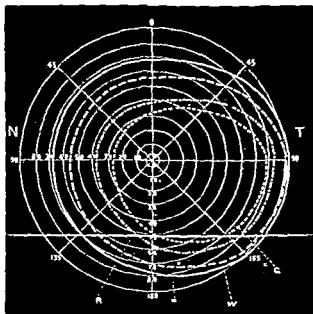Even the ordinary perimetric observation is a relatively rough test and purely subjective   Every student should have

Fig 96 —Perimeter chart of right eye (Landolt)   T, temporal side, N, nasal side   W, for white object   B for blue   R for red, G, for green

his own field taken   he will then appreciate the difficulties which patients experience   The normal physiological response to an object in the peripheral field is to turn the eyes towards it   In charting the field of vision this normal response has to be suppressed, fixation being rigidly maintained while attention is directed to an object at the periphery   Hence the first fields taken must always be regarded with suspicion, and particularly so in the case of dull or neurotic patients   The most variable factor is the illumination and sufficient attention is not usually

paid to this point. With good illumination an object subtending a visual angle of 0 5° will give the full formal field for white. The ordinary 10 mm. object at the distance generally used, viz., 30 cm., *i e.,* 10/300, corresponds with a visual angle of 2°. Deductions made from variations in the colour fields are particularly unreliable (*vide* p 141)

Special care must be taken to investigate the central part of the field for red and green, since conditions are not uncommon, *e g*, tobacco amblyopia and retrobulbar neuritis, in which these colours are not recognised by central vision (*central relative scotomata*) The 5 mm square should be placed over the point of fixation and the colour changed ;
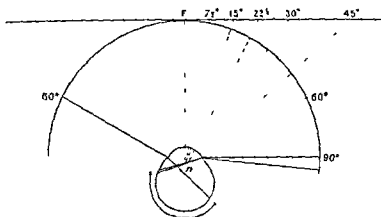
Fig 97 —Diagram of the right eye, showing the relationship of the retina to the degrees of the perimetric arc, and the relative value of the latter when projected on a tangent scale *n*, nodal point F, point of fixation.

blue and yellow will be recognised as such, but not red and green.

(3) For more accurate investigation of details another method must be employed, but it is applicable only to the central and paracentral areas It consists in placing the patient 2 metres from the centre of a large black screen, 2 metres or more in diameter (Bjerrum's screen). The patient fixes a spot in the centre of the screen and smaller circular discs of ivory, 1 mm. to 10 mm. in diameter, attached to a long black rod are brought in from the periphery on a level with the screen. At this distance a 3 mm object subtends a visual angle of about 5 minutes. It will be noticed that, the angles being projected on to a flat surface, tangents are recorded, not

angles themselves as with the arc   Hence only a small area
can be investigated and the distortion must be taken into
account   Some points of diagnostic importance which cannot
be elicited by the perimeter can be brought out by this method
Various *scotometers* have been devised on the principle of
Bjerrum's screen.

If the charts of the two eyes are superposed there will be a
large central area which is common to both eyes   this is the
field of binocular vision

The Light Sense may be roughly tested by means of
Bjerrum's test types, which consist of Snellen's test types
printed grey on a grey background of different intensity , or
it may be tested against the surgeon's as a control by using
the ordinary Snellen's test types and gradually lowering the
illumination   There are considerable individual differences in
the rate of development of dark adaptation and facility of
behaviour under low illumination   These are of great impor
tance in night operations by the combatant services and to
civilians during " black out   Special methods have been
devised for their investigation   The administration of
vitamin A, which is essential to the formation of visual
purple, does not seem to improve scotopic vision unless
it is deficient in the diet   The rate of dark adaptation
may be much prolonged in pathological conditions *e g ,*
retinitis pigmentosa xerophthalmia, glaucoma &c

The Colour Sense requires elaborate apparatus for its
scientific investigation   The methods used will be discussed
later (p 413)

SECTION III

DISEASES OF THE EYE

CHAPTER X

Diseases of the Conjunctiva

THE conjunctiva shows very considerable variations in appearance at different ages and in people who follow various employments The peculiarities of colour, vascularity, laxity, &c, which are consistent with health can be learnt only by repeated observation

It is necessary for a scientific appreciation of pathological conditions to be cognisant of the normal structure of a part The conjunctiva is divided into two portions, palpebral and bulbar, the folds uniting these parts are the fornices The palpebral conjunctiva is said to commence at the anterior margin of the edge of the lid, but from this point to the posterior margin of the edge (the intermarginal strip) and for about 2 mm beyond (to the sulcus subtarsalis) there is a transitional zone covered with stratified epithelium and partaking of the characters of both skin and conjunctiva (Chap XXXI) There are two layers of epithelium over the palpebral conjunctiva from the fornices to the limbus the epithelium becomes gradually thicker, forming eventually again a stratified epithelium Below the epithelium is an adenoid layer, consisting of loose connective tissue containing mononuclear lymphocytes below this a fibrous layer, much denser and passing insensibly into the underlying tissues—lid or sclerotic The palpebral conjunctiva is firmly adherent to the tarsus, while the bulbar portion is freely movable over the sclerotic except close to the cornea

Bacteriology The conjunctival sac is practically never free from organisms Owing to the relatively low temperature of the conjunctival sac due to exposure evaporation of lacrymal fluid and moderate blood supply, bacteria do not propagate themselves readily The tears are not a good

culture medium, and though they contain lysozyme, they cannot be regarded as actively bactericidal They contain no agglutinin, and diphtheria antitoxin does not pass into them when present in the blood Hence they act principally in a mechanical manner, washing away dele terious agents and their products The presence of dust, even if it be sterilised, augments the bacterial content of the conjunctival sac It is also increased by bandaging owing to the arrest of movement of the lids and the raised tempera ture of the sac Most of the organisms normally present are non pathogenic, but some of these are morphologically identical with pathogenic organisms Diplococci indistinguishable from pneumococci are found , they may be innocuous to animals or prove themselves true pneumococci The conjunctiva of many people is immune to pneumococcic infection, though the same germs transferred to other persons will excite a violent inflammation It may be stated at once that the pneumo coccus is one of the most dangerous organisms in the pathology of the eye Another bacterium, the so-called xerosis bacillus, is morphologically identical with the diphtheria bacillus , it can only be distinguished by skilled examination of cultures Staphylococci are found , they are relatively innocuous in the absence of other organisms, but play an important part in mixed infections Staphyloccoccus albus and xerosis bacilli are frequently present in the normal conjunctival sac There are reasons for thinking that their presence favours the growth of pathogenic bacteria thus xerosis bacilli promote the multiplication of Koch Weeks' bacilli both in cultures and on the conjunctiva Streptococci, Bac coli, &c , are patho genic, but rare Other pathogenic organisms—gonococci, Koch Weeks' bacilli, diplobacilli—will be discussed later

the increased secretion is almost wholly a reflex secretion of tears. A foreign body, especially a grain of corn or the wing capsule of an insect, may be retained in the fornix and set up a violent unilateral conjunctivitis. Irritation limited to the lower fornix may be artificial in malingerers and hysterical patients.

Recurrent or chronic congestion may be caused by the conditions of life—dusty, ill ventilated rooms, exposure to strong light, &c. Bright light, especially exposure to tropical sunlight, acts partly by the glare due to the luminous rays, partly by the chemical action of the actinic, especially the ultra violet rays and partly by the heat, which is chiefly due to the infra red rays. Chronic congestion is often due to conditions remote from the conjunctiva itself. Very frequently it is a reflex irritation due to errors of refraction, in such cases the edges of the lids may participate. Other causes are found in errors of metabolism—gout, over eating and drinking, and so on. It is a characteristic symptom of hay fever, and in this case there is an excess of eosinophile leucocytes in the conjunctival secretion.

Simple hyperæmia of the type described causes a sense of discomfort, often described as tightness, grittiness, inability to keep the eyes open, tiredness &c. Bright light is resented, but there is seldom true photophobia. The conjunctiva often looks quite normal until the lower fornix is exposed, when it will be seen that the parts in contact are congested and sticky. The discomfort frequently comes on only in the evening or after near work. In the gouty cases there may be œdema—chemosis.

Chemosis affects the most loosely attached parts of the conjunctiva, *i e*, principally the bulbar conjunctiva and fornices. The mucous membrane becomes swollen and gelatinous in appearance. The swollen membrane forms a wall around the cornea, which it may overhang in severe cases. The palpebral conjunctiva is little affected, but the tissues of the lid are often also œdematous, so that the lids are swollen and *the upper hangs down over the lower*.

Whenever watering of the eyes is complained of, and when ever only one eye is congested or shows signs of conjunctivitis, the lacrymal passages must be investigated. Pressure with the finger backwards and inwards over the lacrymal sac may cause regurgitation of fluid—tears, mucus, or pus—showing that the outflow into the nose is obstructed. If no regurgitation can be detected, the position of the lower punctum must

be noted It ought to be invisible until the lid is slightly everted /

The *treatment* of simple hyperæmia consists primarily in the removal of the cause Defective conditions of life must be ameliorated if possible The irritation of strong light must be removed, or modified by the use of dark glasses If the light is not very excessive ordinary neutral tinted ("smoked ") glasses will suffice They are better than blue or other coloured glasses as they reduce the intensity of the luminous rays more uniformly throughout the spectrum Nearly all kinds of glasses cut off a large percentage of the ultra violet rays especially those of shortest wave length Sir William Crookes prepared a series of synthetic glasses which have various absorptive powers Some of these cut off practically all the infra red and ultra violet rays, while absorbing the luminous rays to only a slight degree Tinted Crookes's glasses are specially indicated for use in tropical climates and for winter sports

Errors of refraction must be corrected It should be remembered that the error may be artificial, through the use of wrong spectacles The amount and conditions of near work should be specifically stated

Defects of the lacrymal apparatus must be treated (Chap XXXII) If no defect is noted local treatment of the hyperæmia is ordered for a time, but if the condition does not improve the patency of the lacrymal passages must be demonstrated by syringing The beginner must be careful however, that he does not do harm rather than good

Errors of metabolism must be treated on general medical principles Such causes are easily overlooked, hence they should be specially borne in mind

Local treatment consists in bathing the eyes frequently with warm boric lotion, with or without a mild astringent, *e g*, zinc sulphate, gr ½ or 1 to ℥1 A drop of a mixture of equal parts of tincture of opium and distilled water night and morning, will be found soothing Hazeline, 20 minims to ℥1, is sometimes useful, but varies in its effect in different people Cocaine must be used with diffidence its effects are transitory, and it has a deleterious action upon the corneal epithelium, but in quite weak doses often affords much comfort

In cases where temporary alleviation—usually of the disfiguring signs—is insistently desired a drop of adrenaline solution (1 in 1000) instilled into the eye will remove the discomfort and reduce the redness of the conjunctiva The

effect is, however, very transitory, but it will often earn gratitude. It is especially useful after the removal of a foreign body from the corner.

The nature of the secretion in conjunctivitis is of diagnostic importance. It may be watery, mucous, muco-purulent, or purulent, and the disease is often classified accordingly. Most forms of acute conjunctivitis are due to bacterial agency. Unfortunately, each pathogenic organism does not produce a specific clinical picture. It is therefore wise in the meantime to retain the old clinical terminology.

Watery secretion is usually due to reflex secretion of tears. The other types of secretion show some relation to the bacterial cause, and must be distinguished on account of the information they convey as to the probable severity of the condition and the indication they provide for special measures of treatment.

The chief forms of conjunctivitis may be divided into two groups acute, and sub-acute or chronic. Acute conjunctivitis may be classified as simple acute (including muco-purulent), purulent, membranous, and phlyctenular. Sub-acute or chronic conjunctivitis includes simple chronic conjunctivitis, angular conjunctivitis, follicular conjunctivitis, trachoma, tubercle, and syphilis.

Simple Acute Conjunctivitis (Syn.—Catarrhal Conjunctivitis). The condition described as hyperæmia of the conjunctiva passes imperceptibly into a condition characterised by greater and more general hyperæmia and a thicker mucous discharge which gums the lids together. The lids are usually described as being stuck together in the mornings, because the condition is most noticed after they have been closed for a considerable period. The causes, symptoms, and treatment are the same as in simple hyperæmia.

Various more intense forms of simple acute conjunctivitis are met with. They are probably all of bacterial origin, the organisms differing in different cases. Among the lower classes the disease is called "blight" and it is commonly attributed to a "cold in the eye" Cold probably acts only by lowering the resistance of the tissues to the action of organisms.

The commonest form is Muco-purulent Conjunctivitis. Here, as the name implies, the secretion is muco-purulent, it is more profuse than in the simpler forms. As in most cases of conjunctivitis the disease is contagious, being transmitted directly by the discharge and possibly by the air of ill ventilated

rooms, though this method is doubtful, since most of the organisms are non sporing and are easily destroyed by drying The whole conjunctiva is a fiery red (' pink eye '), all the conjunctival vessels are congested except the circumcorneal zone in the milder cases (*vide* p 83) Flakes of muco pus are seen in the fornices, and often between and upon the margins of the lids If the discharge is allowed to dry the lashes become matted together by dirty yellow crusts These may be easily mistaken for the condition found in blepharitis, but, if the crusts are bathed off the underlying lid margins will be
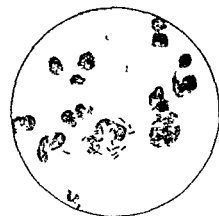
found healthy Flakes of mucus passing across the cornea often give rise to coloured haloes, owing to their prismatic action These "haloes" must be c a r e f u l l y distinguished from those met with in glaucoma (*q v*)

The discharge is at first mucous, but gradually becomes more purulent Beginners are liable to mistake muco purulent for true purulent conjunctivitis In the former, the more purulent masses are found among the lashes

Fig ʻ8 —Koch Weeks bacilli
(× 1000)

and at the inner canthus, whilst the fornices and bulbar conjunctiva show only flakes of translucent or yellowish secretion In the latter, crusts of inspissated pus may be seen among the lashes and at the canthi but when the lids are separated fluid pus wells out

The disease reaches its height in three or four days if untreated it is liable to pass into a less intense, chronic condition Complications are rare, but abrasions of the cornea are liable to become infected and to give rise to ulcers Occasionally marginal ulcers form—in debilitated or old people or as the result of improper treatment

Muco purulent conjunctivitis frequently complicates phlyctenular conjunctivitis

Pathology Muco purulent conjunctivitis is frequently caused by the Koch Weeks' bacillus (Fig 98) This is a very slender rod varying much in length It stains badly with the

ordinary basic dyes e g Loffler s methylene blue it is decolourised by Gram Groups of bacilli found in much degenerated ' skeletonised ' pus cells are very characteristic

The organism is rapidly destroyed by drying It has been known to give rise to very definite epidemics In England the cases are usually sporadic though moderate transmission is common An attack confers immunity for some time

The Koch Weeks bacillus is by no means the only cause of muco purulent conjunctivitis Diplococci which are indistinguishable from pneumococci (Fig 99) also cause it probably more frequently in England Pneumococcic conjunctivitis though not definitely separable from the other acute forms clinically shows distinct tendencies which should be borne in mind the more so since the pneumococcus is the cause of hypopyon ulcer (q v) There is usually more œdema (chemosis) small ecchymoses are common and a membranous film may form— pseudo membranous conjunctivitis It is commonest in northern countries and in the cold weather, and

Fig 99 —Pneumococc (× 1000)

is more often found in children than adults It ends with a crisis like pneumococcic infection of the lungs after which the organism rapidly disappears from the secretion It is often accompanied by nasal catarrh which may precede or follow the inflammation Iritis is very rare as a sequel of conjunctivitis but pneumococcic conjunctivitis is exceptional in this respect The inflammation of the iris is set up by absorption of tox ns (cf Hypopyon Ulcer of the Cornea)
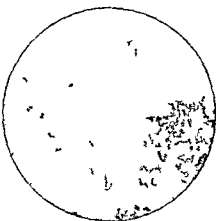
The influenza bacillus which is distinguished with difficulty from the Koch Weeks bacillus is responsible for conjunctivitis during influenza epidemics more often in children than adults

The muco purulent conjunctivitis associated with phlyctenular conjunctivitis is usually due to staphylococcus aureus which may also set up conjunctivitis in cases of blepharitis and eczema or impetigo of the skin The organism sometimes

causes a muco purulent discharge after cataract extraction and other operations, and also in the new born probably owing to the defective resistance of the tissues in these conditions In the presence of irritating dust a staphylococcic conjunctivitis of slight intensity may be set up The presence of staphylococci is liable to aggravate conjunctivitis set up by some other organism

Other organisms have been found, but their ætiological relationship to the disease is not proved

Muco-purulent conjunctivitis generally accompanies or follows measles and frequently scarlet fever It also occurs with acne rosacea, when minute nodules, somewhat like phlyctens, form at the limbus and on the cornea It frequently recurs in these cases, and is intractable Muco purulent conjunctivitis sometimes occurs among people who use swimming baths (ι p 182) It often spreads rapidly through schools and other such institutions

Fig 100 —Undine

Treatment The best treatment for muco-purulent conjunctivitis is the frequent washing out of the conjunctival sac with lotio hydrargyri perchloridi (1 to 10,000) (called hereafter sublimate lotion) It should be warmed and diluted by the addition of a little boiling water The lotion must not be simply applied to the lids It is well for the surgeon himself or a competent nurse to wash out the conjunctival sac the first time For this purpose an "undine" (Fig 100) is the most convenient reservoir The lids are everted and the lotion is poured from a little height over the whole surface, every crevice being irrigated as thoroughly as possible The nozzle of the undine should not be allowed to touch any part of the eye The patient may be directed to use the ordinary eyebath for the application of eye lotions If a child, the parents should be instructed to hold the lids apart, the child lying upon its back A pad of cotton wool dripping with the lotion, which may be warmed, is then held over the eye and the lotion squeezed out the process is repeated until all discharge has been washed away The lotion may be warmed by placing the bottle in hot water, but the addition of an equal part of hot water suffices, eye lotions act chiefly by washing out deleterious material, since they cannot be used sufficiently strong

to act as efficient antiseptics. For this reason boric acid lotion is probably nearly as efficacious and is less irritating. Indeed, boric acid lotion or even normal saline solution should be ordered for nervous people who are afraid of a little pain, since it is useless to bathe the eyes unless the fluid irrigates the conjunctival sac.

Boric acid ointment or sterile vaseline is smeared along the lids at bed-time, or, in children, as often as they are put to sleep: it prevents the lids from sticking together—a two-fold benefit, that of preventing discharge from being retained, and that of obviating pain on opening them.

The eyes should not be bandaged, as it prevents the free exit of the secretion. If there is any photophobia a shade or dark goggles should be worn. The patient should spend as much time out of doors as possible.

If this treatment is properly carried out, the patient will be well in a few days. Even if only partially successful there will then be less discharge.

If the case is not progressing as rapidly as could be desired, or the attendants are not reliable, and if the discharge is subsiding, it is wise to paint the lids once with silver nitrate solution (gr. x. to

Fig. 101.—Glass rod.

3 i.) This is the strength which should always be used for painting lids. Stronger solutions act too vigorously as caustics, and, if a caustic effect is desired, it can be obtained with greater precision by other means. Weaker solutions are precipitated by the chlorides in the lacrymal secretion, so that they are practically useless.

The following is the best method of painting lids. A glass rod is used, tapering at each end (Fig. 101). The finger should be passed over the ends each time before use to make sure that they are not chipped. The end is dipped in lotion to damp it. A *very thin* wisp of cotton-wool is then tightly wound round the end, starting where it begins to taper: this fixes the wool. The end of the wisp is left loose, so that it may absorb the solution. The other end of the rod is armed in the same manner.

The patient, if a child, is placed upon his back. The lids are everted ; the wool, dipped in the silver solution, is applied freely to the conjunctival sac, the cornea being protected as much as possible. It is quite unnecessary to neutralise the excess of nitrate with salt solution, as is often taught. The

excess may be mopped up with a pad of dry absorbent wool
If, as is usually the case, the other eye is affected, the other
end of the rod is used in the same manner   In the absence
of a glass rod the best implement is an ordinary wooden
match, used in the same way   The match can be thrown away
after use   The glass rod must be sterilised by boiling   A
camel's hair brush should not be used   it cannot be kept
aseptic

A single painting with silver nitrate will often produce an
excellent result   It is good as a prophylactic if discharge is
inadvertently introduced into a normal eye   Other prepara
tions of silver—protargol (20 per cent), argyrol (25 per cent),
&c—are not so efficacious, but they have the advantage of
being less painful

Silver nitrate acts by forming a thin epithelial eschar and
coagulating the muco purulent discharge   The bluish white
film is cast off in flakes, and until this process is complete the
feeling of a foreign body in the eye is experienced   The irrita
tion is reduced if the lid is kept everted for a few minutes and
the flakes gently removed with cotton wool, a drop of 2 per
cent cocaine solution being then instilled   Silver nitrate is
not strongly bactericidal, but the organisms are entangled in
the coagulum and removed with it   Moreover there is a
powerful physiological response to the caustic , hyperæmia
increases and the tissues are flooded with blood serum, which
can thus more effectively exert its bactericidal and antitoxic
powers   The slighter efficacy of protargol and the modern
colloid substitutes for silver nitrate is to be attributed to their
smaller caustic and irritant properties which are often regarded
as their chief advantages

The conjunctiva generally returns to a perfectly normal
condition   If the case has been neglected and chronic inflam
matory signs persist, astringents should be used as for chronic
conjunctivitis (q)

Since the disease is contagious care must be taken to prevent
its spread   The patient must keep his hands clean and no
one else must be allowed to use his towel, handkerchief, &c

Purulent Conjunctivitis (Syn —*Acute Blennorrhœa, Gonor
rhœal Conjunctivitis*) is a much more serious condition   It
occurs in two forms—as ophthalmia neonatorum in babies,
and as gonorrhœal conjunctivitis in the adult   Certainly the
former, and probably the latter, is not invariably gonorrhœal

Gonorrhœal Conjunctivitis (Syn —*Acute Blennorrhœa of
Adults, &c*)   Gonorrhœal conjunctivitis is even more serious

in the adult than in babies, fortunately, considering the prevalence of gonorrhœa, it is comparatively rare (1 in 700—800 cases) While generally due to the gonococcus it is important from the medico legal point of view to remember that the same features may be found with streptococci, diphtheria, and with mixed infections The gonococcus is a bun shaped diplococcus, staining readily decoloured by Gram and found within both leucocytes and epithelial cells (Fig 102) The micrococcus catarrhalis and the meningococcus, both Gram negative, are sometimes found in the conjunctival sac They may be distinguished from the gonococcus by the ease with which cultures are obtained and by agglutination tests

The micrococcus catarrhalis is rarely found in acute conjunctivitis, but more often in chronic and post operative forms

The disease is due to direct infection from the genitals Males suffer most, the right eye before the left in a right-handed person There is more swelling of the lids and conjunctiva than in children copious purulent discharge, more tendency to involvement of the cornea, and marked constitu

Fig 10.—Gonococci (× 1000)

tional disturbance—rise of temperature, and so on, but especially very marked depression of spirits (The greater danger to the cornea is due to the chemosis, which produces blood and lymph stasis and facilitates the retention of secretion)

The incubation period is a few hours to three days The upper lid becomes enormously swollen and tense, overhanging the lower, and edged with pus Eversion, which is difficult, shows that the palpebral conjunctiva is deep red and velvety rarely there is a membrane Occasionally the discharge is sanious rather than purulent, especially in streptococcic cases There is great pain, the preauricular gland is enlarged and tender, and may suppurate

After two or three weeks the purulent discharge diminishes but subacute conjunctivitis with much papillary thickening of
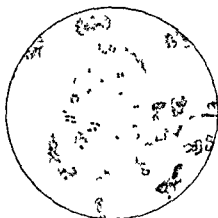
the conjunctiva persists for several weeks longer The gono
coccus is still present—a point of great importance, both as
regards contagion and treatment No immunity is conferred
by the attack

The most important point in diagnosis is the coincidence of
urethritis The most important point in prognosis is the con
dition of the other eye

Corneal complications are the rule and constitute the causes
of blindness There may be diffuse haziness of the whole
cornea, with grey or yellow spots near the centre Ulcers
may occur at any part and are due to necrosis of the epithe
lium through direct invasion by the organisms Marginal
ulceration which may extend completely round the cornea,
is due to retention of pus in the angle formed by the chemotic

conjunctiva When ulceration
has commenced it progresses
rapidly and deeply, since the
tissues are bereft of their first
line of defence—the epithe
lium Perforation is therefore
common, with all its atten
dant dangers (*vide* p 202)
Ulceration commencing late in
the history is not so dangerous

The greatest care should be
taken to prevent injury to
the cornea during the manipu
lation necessary for diagnosis
and treatment Abrasions are
easily produced by the finger
nails, and even by the rough use of wool swabs Such
abrasions rapidly become dangerous ulcers
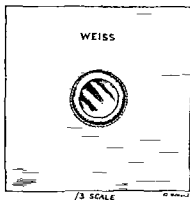
FIG 103 —Buller's shield

Iritis and iridocyclitis with attendant complications, may
arise independently of perforation of the cornea, and lead to
serious diminution of vision

Gonorrhœal arthritis is not uncommon and endocarditis
and septicæmia may arise as complications

Treatment must be directed first to protection of the
other eye This is at once sealed up with a Buller's shield
which consists of a watch glass stuck in a frame of ad
hesive plaster, or better, rubber (Fig 103) The rubber is
hermetically sealed down to the face and nose except at
the lower outer angle, where a small piece of tubing is
inserted under the edge If this means of ventilation is

not adopted the glass becomes hazy and the eye cannot be properly observed, moreover, the irritation to the eye is greater. Special attention should be directed to fixing the shield near the nose, i.e., on the side of the source of infection. Patients should be told to sleep lying on the same side as the affected eye.

If the second eye should show signs of infection it must be treated, but every utensil or dressing which is applied to the eye must belong to a totally different set from that used for the worse eye, otherwise it may be inoculated rather than treated. The less affected eye must always be dressed first.

If pus from a gonorrhoeal conjunctivitis spurts into the surgeon's eye, the conjunctival sac should be freely irrigated with sublimate lotion and the lids painted once with silver nitrate (vide p 113). The eye should be carefully watched, but no further drastic treatment applied unless conjunctivitis supervenes. The accident is due to carelessness, for every attendant on a gonorrhoeal case should wear protective goggles.

If the disease is fully established and there is abundant purulent discharge, the eye must be irrigated every two hours during the day and every four hours during the night with warm saline (0.85 per cent), boric, or weak sublimate lotion (1 in 8000), mercurochrome (1 per cent), or acriflavine (1 in 1,500). Iced wet dressings are applied in the intervals, but are to be bandaged on quite loosely, so as to avoid retention of discharge. The patient is kept in bed, and if intelligent, can bathe his lids in iced lotion in the intervals. Iced applications afford much relief to the patient, though hot ones are probably more efficacious.

Most reliance must be placed on applications of silver nitrate, but they must be used with discretion. They are specially indicated in gonorrhoeal conjunctivitis because the gonococcus is an intracellular organism. As already stated (p 154) silver nitrate destroys the superficial layer of epithelial cells, which is cast off as filmy eschar, carrying the entangled organisms with it. When not contra indicated the conjunctiva of the everted lids should be well painted with silver nitrate, gr x to ʒ i, not oftener than once a day. Special care must be taken to avoid injury (vide p 89). This treatment is contra indicated in the very early stage before free discharge has set in, and also in later stages if there is much brawny swelling with comparatively little discharge. Under these conditions the stasis is so great that reaction is inefficient, the caustic, in

fact, induces the necrosis which it should be our endeavour to avoid In such cases hot applications and leeches should be relied upon The latter are applied over the temporal region near the outer canthus If the lids are very tight the outer canthus should be split (canthoplasty) The ends of strong blunt-pointed scissors are inserted between the lids into the angle under the outer canthus, which is then divided by a single snip in a horizontal direction This has the good effect of bleeding the patient slightly, and also of giving free exit to discharge

Sulphapyridine (M & B 693) has proved very successful in gonorrhœal infections, and should be used as described on p 693

Since no general immunity is conferred by the organism active immunisation with a gonococcic vaccine is useless Milk injection appears to have a beneficial effect if given in the early stages (*vide* p 694) if the reaction is not too great it can be repeated once or twice, but if these fail further injections are useless

It is of great importance to attend to the general health The bowels must be kept freely open The strength must be reinforced by every available means—good foods, tonics, alcohol if necessary An occasional sleeping draught and the use of sedatives must be ordered according to general principles Every effort must be made to combat the depression from which these patients suffer

In the final stage of the disease silver nitrate should be used at increasing intervals for a week or fortnight after the purulent discharge has ceased Astringent lotions are then employed (*vide* p 172)

Atropine should be used in all cases where the cornea is involved, since this is always accompanied by some iritis, but the intraocular tension should be watched

Corneal complications require very active treatment (*vide* pp 204, *seq*)

Metastatic Gonorrhœal Conjunctivitis sometimes occurs in adults, associated with gonorrhœal arthritis It is a mild simple conjunctivitis, generally bilateral, and occasionally accompanied by iritis It is probably due to endogenous infection from gonococci in the blood It usually responds readily to local treatment, but is apt to recur if the arthritis relapses

Ophthalmia neonatorum is a preventable disease occurring in new born children as the result of carelessness at the

time of birth, it is responsible for 50 per cent of blind children and about 7—8 per cent of all blind people (8 per cent in U.S.A., de Schweinitz) It is difficult to obtain reliable statistics, especially since all cases of discharge from a baby's eyes within three weeks of birth have become notifiable as ophthalmia neonatorum (*vide* p 161) It is obvious that a large proportion of these cases are not ophthalmia neonatorum in the narrower sense of the term True ophthalmia neonatorum is due to infection by vaginal or faecal matter, or from dirty rags used to clean the eyes Purulent discharge is usually noticed on the third day, when it occurs later it is generally due to post-partum infection In rare cases the disease is already present at birth

Any discharge, even a watery secretion, from a baby's eyes during the first week should be viewed with suspicion, since tears are not secreted at this early date In cases of infection the discharge rapidly becomes muco purulent and then puru lent Both eyes are nearly always affected, though one is usually worse than the other The conjunctiva becomes intensely inflamed, bright red, and swollen, and pours out thick yellow pus Marked chemosis is a distinguishing feature from severe muco purulent conjunctivitis, and when the lids are separated by retractors the cornea is seen at the bottom of a crater like pit There is dense infiltration of the bulbar conjunctiva, and the lids are swollen and tense Later the lids become softer and more easily everted, the conjunctiva becomes puckered and velvety, and the blood stasis gives place to intense congestion, with free discharges of pus, serum and often blood In some cases a false membrane forms, so that the case resembles a membranous conjunctivitis

There is great risk of corneal ulceration in ophthalmia neonatorum, especially, as is usually the case, when it is due to the gonococcus, which has the power of invading intact epithelium The slightest haziness of the cornea should be viewed with apprehension Often the cornea is already ulcerated, and not infrequently perforated, when the child comes under observation Ulceration usually occurs over an oval area just below the centre of the cornea, corresponding with the position of the lid margins when the eyes are closed, and consequently, rotated somewhat upwards More rarely oval marginal ulcers are formed as in the gonorrhœal conjunc tivitis of adults, or the ulceration may be central The ulcers extend rapidly, both superficially and in depth, largely owing to lymph stasis due to strangulation of the nutrient vessels

Perforation is usually signalised by a black spot or area in the ulcer, caused by protrusion of the iris   Sometimes perforation is sudden, a large part of the iris prolapses, and the lens may be extruded   In some cases there is a black hole in the cornea, filled with clear vitreous

Metastatic stomatitis and arthritis occur rarely, as in gonorrhœal urethritis   The arthritic manifestations usually appear in the third or fourth week and affect knee, wrist, ankle, or, sometimes, elbow   The course is benign, abscesses being rare

The baby's eyes must be examined as described in method (4), p 81   The surgeon must wear protective goggles lest pus spurt into his eyes when the child's lids are separated   Retractors must always be used for separating the lids, since the slightest pressure on the eyeball may result in perforation (*vide* p 89)

A bacteriological examination should be made in every case.

Pathology   Probably 60—70 per cent of cases are due to the gonococcus   The bac coli is responsible for some of the remainder, probably through fæcal infection , pneumococci, streptococci and mixed infections for others   Streptococcic conjunctivitis is even more virulent than gonococcic, the cornea being in imminent danger

Sequelæ of Ophthalmia Neonatorum   If the corneal ulceration heals without perforation there is always much scarring of the cornea   but the nebula clears more in babies than in older people   Perforation may be followed by anterior synechiæ (*q v*), adherent leucoma (*q v*), partial or total anterior staphyloma (*q v*)   anterior capsular cataract (*q v*), panophthalmitis, &c   Ophthalmia neonatorum is the commonest cause of anterior staphyloma

When vision is not completely destroyed, but is very seriously impaired by the corneal opacities resulting from ophthalmia neonatorum, the development of macular fixation, which takes place during the first six weeks of life, is interfered with, resulting in the development of nystagmus (*q v*), which persists throughout life   Nystagmus may not become manifest until some considerable period after the ophthalmia

Treatment   The disease is preventable, *prophylactic* treatment is therefore of prime importance   Any suspicious vaginal discharge during the antenatal period should be treated   The new born baby's closed lids should be thoroughly cleansed and dried   The lids are then separated, and a drop of silver nitrate solution, 1 per cent , instilled into each eye

(Crede's method) The eyes must be carefully watched during the first week.

If the disease is established the eyes must be irrigated every two hours with saline or preferably sublimate lotion, and the lids painted once daily with 2 per cent silver nitrate (*vide* pp 153, 157) The surgeon or nurse must wear protective goggles and rubber gloves In irrigating or painting the greatest care must be exercised to avoid touching the cornea, thus injuring the already softened epithelium Argyrol, protargol, and other colloid preparations of silver must not be used instead of silver nitrate, but may be used as drops in the later stages when the critical period has passed The slightest sign of corneal haziness is an indication for the use of atropine, 0 5 per cent (*vide* p 204) Boric acid ointment should be used to prevent the lids from sticking together, or the atropine may be used in the form of an ointment Eusol (1 in 10) for irrigation and acriflavine (1 in 1,500) in castor oil as drops are used at St Margaret's Hospital Sulphapyridine (M & B 693) has proved very successful in ophthalmia neonatorum, and should be used as described on p 693 Protein shock by milk injections have proved beneficial 1 c c increased to 2 or 3 c c every third day, according to the febrile reaction, is the suitable dose (*vide* p 694)

The Prevention of Ophthalmia Neonatorum and Blindness due to this Cause Though ophthalmia neonatorum is a preventable disease, and much attention has been directed to its prevention, it still remains the cause of a large amount of blindness It was made notifiable throughout England and Wales in 1914, being defined as a "purulent discharge from the eyes of an infant commencing within twenty one days of birth" Under the rules of the Central Midwives Board every midwife is required, under severe penalties, to call to her assistance a medical man in any case of "inflammation of or discharge from the eyes of the child," however slight," and to send notice to the supervising authority that medical help has been sought The administrative measures ensure that mid wives' cases come promptly under the supervision of medical officers who are accustomed to deal with this class of case There is evidence that some medical practitioners fail to recognise early and notify promptly cases of ophthalmia neonatorum, with the result that efficient treatment is not begun early enough to prevent serious impairment of vision or even blindness

Since most of the worst cases of ophthalmia neonatorum are gonorrhoeal, the combating of this disease should diminish

the incidence of blindness As already mentioned, ante-natal measures should be adopted, whenever possible, to cure disease causing abnormal vaginal discharge in the mother Next, the greatest care should be exercised to avoid vaginal discharge reaching the eyes of the baby at birth " As soon as the child's head is born, and if possible before the eyes are opened, its eyelids must be carefully cleansed They should be thoroughly wiped with clean material such as cotton-wool, lint, or rag, using separate pieces for each eye . . . When the baby is bathed the discharges with which its body is covered during labour are washed off into the bath water If its face is washed in this water matter may get into the eyes " (*Instructions to Midwives, by Central Midwives Board*)

Prophylactic Drugs In the hands of medical men Credé's method has been most successful and is to be recommended, especially in cases where abnormal vaginal discharge is known to exist It is not, however, to be recommended for universal use by midwives for the following reasons (1) The midwife may be apt to think that, having dropped a little solution into *the eye, she has done all that is necessary, and consequently* neglect the scrupulous cleansing which is even more important , (2) the use of drugs will induce an inflammatory re action which, on the one hand, she may mistake for the onset of the disease and notify accordingly , or (3) on the other hand, she may regard as " only a little reactionary discharge " what is really a manifestation of the disease itself , (4) the wrong *solution may be used* there are several cases on record of strong nitric acid, probably supplied for urine testing, having been dropped into the baby's eyes in mistake for silver nitrate Owing to the proved efficacy of Credé's methd od and improved administrative arrangements these arguments have lost some of their force

When ophthalmia neonatorum has actually developed, a medical practitioner who has not had very thorough training and experience in the treatment of the disease should at once obtain the assistance of an ophthalmic surgeon It is to be remembered that any discharge from a baby's eyes during the first week of life is pathological, and no risks should be taken Given satisfactory home conditions, competent medical supervision, and skilled nursing, home treatment gives the best results In many cases these requirements *cannot be* fulfilled In these cases probably the ideal method is to transfer both mother and child to a hospital where special provision is made for such cases This is possible in London

at St Margaret's Hospital, and also in most other large towns and in many county boroughs, but it is eminently desirable that similar provision should be made in suitably distributed General or Ophthalmic Hospitals since special hospitals for the purpose are liable to become stigmatised as venereal hospitals Failing this method of dealing with the case, the child should be taken daily to the out patient department of a General or Ophthalmic Hospital, and the eyes irrigated as often as possible by a competent nurse at home This method is fairly satisfactory in all but the worst cases but is not always practicable in outlying districts

Membranous Conjunctivitis (Syn —*Diphtheritic Conjunctivitis*) As in inflammation of the throat the surface may become covered by a fibrinous membrane so the same may occur in the conjunctiva, and just as the milder clinical varieties in the former were distinguished as croupous from the severer or diphtheritic so also with conjunctivitis It has been placed beyond dispute however that mild cases may be diphtheritic and severe non diphtheritic, hence it is best to speak simply of membranous conjunctivitis until a bacteriological examination has placed the matter beyond dispute A variety of organisms other than the diphtheria bacillus, e g, pneumococcus streptococcus can produce a membrane, especially in weakly children e g after measles and scarlet fever and in association with impetigo, these cases are sometimes called pseudo membranous They cannot be distinguished clinically with certainty

Membranous conjunctivitis occurs chiefly in children and shows all degrees of severity it may be as virulent as the worst cases of gonorrhœal ophthalmia It is rare in England, but it is of the utmost importance that it should be recognised when seen, not only on account of the grave danger to the eye, but also from the risks of contagion

In mild cases there is some swelling of the lids and a muco purulent or sanious discharge On everting the lids the palpebral conjunctiva is seen to be covered with a white membrane, which peels off readily without much bleeding

In severe cases the lids are more brawny the conjunctiva is permeated with semi solid exudates, which impair the mobility, compress the vessels, prevent the formation of a free discharge, and tend to necrosis of both of the conjunctiva and cornea Here the membrane separates much less readily, the underlying surface bleeding unless it is too infiltrated and solid The membrane may be patchy or cover the whole

palpebral conjunctiva often beginning at the edge of the lid It is seldom found on the ocular conjunctiva The preauricular gland may be enlarged and may suppurate The temperature is raised unless the patient is in a moribund condition Albumin is frequently present in the urine

For six to ten days there is great peril to the cornea Then the sloughs begin to separate and the discharge becomes more profuse In a few days the conjunctiva assumes a red and succulent appearance There is danger now of adhesions forming between the palpebral and bulbar parts of the conjunctiva (symblepharon)

Post diphtheritic paralysis even of accommodation is rare

Cases of less severe but more chronic membranous conjunctivitis are occasionally met with In them the membrane is cast off but occurs again and again The pathology of these cases is not understood it has been seen as a complication of erythema multiforme

Fig 104   Diphtheria bacilli (×1000)

Pathology Competent bacteriologists have shown that there is little or no relationship between the severity of the local condition and the presence or absence of the Klebs Loffler bacillus (Fig 104) Only series of cases in which positive results have followed inoculation into animals are absolutely trustworthy owing to the difficulty of distinguishing the diphtheria from the xerosis bacillus with which it is morphologically identical The pseudo-diphtheria bacillus forms little or no acid in culture and is not virulent for guinea pigs and the different varieties may be distinguished by agglutination tests Neisser s stain (acetic methylene blue and Bismarck brown) demonstrates blue granules at the poles of true diphtheria bacilli in cultures of nine to twenty four hours Inoculation tests only are absolutely reliable

Other cases may be due to the action of heat caustics severe atropine irritation herpes iris and other non bacterial causes

Other bacteria which occasionally form membranes

are pneumococcus streptococcus, Koch Weeks' bacillus, gonococcus, staphylococcus, Friedlander's pneumonia bacillus, bacterium coli, &c Streptococcic conjunctivitis, a very virulent form, occurs chiefly in children associated with measles, scarlet fever, whooping cough, and influenza

It is quite rare to obtain evidence of *primary* diphtheria of the throat, though the disease may have been derived from a case of faucial diphtheria and extension to the nose and throat by way of the lacrymal sac and nasal duct occurs The genitalia should be examined for diphtheria or leucorrhœic discharge.

Treatment Every case should be treated as diphtherial unless good negative evidence is afforded by films and serum cultures In mild cases isolation need not be strict until the bacteriological report is obtained on the second day

The treatment is essentially that of purulent ophthalmia, with one important exception, viz , that painting with nitrate of silver is not to be resorted to Further, *canthoplasty is not to be done*, since both these procedures increase the area from which *toxins may be absorbed*

Local treatment consists of irrigations and hot bathings as for purulent ophthalmia (*q v*) One drop of atropine should be instilled at the commencement of treatment Quinine lotion, gr iii to ʒ i , with a minimum of acid to dissolve the salt, has been recommended

The most important general treatment is the administration of antitoxin as in faucial diphtheria Since the antitoxin is innocuous it should be used at once in every doubtful case I have obtained benefit by local instillations of antitoxin, which is a rational procedure but seems to have been neglected Special attention should be paid to the nutrition, and tonics are indicated

Corneal complications must be suitably treated (*vide p 204*) Antitoxins are specially useful as may be shown by experiment If diphtheria toxin is injected into the cornea of two rabbits and one is given an intravenous injection of antitoxin, the cornea of this animal will remain clear, whereas that of the other will become cloudy Corneal ulceration, however, is usually due to secondary infection with pyogenic organisms It may start at the middle or margin of the cornea and is not wholly due to interference with nutrition

In streptococcic membranous conjunctivitis the danger of necrosis of the cornea and even of the death of the patient is such that immediate recourse should be had to a specific antistreptococcic serum The remarkable results of treatment

of other streptococcic conditions, *e.g.*, puerperal fever, with sulphanilamide indicate that it should be tried in these cases (*vide* p. 693).

Phlyctenular Conjunctivitis (*Syn.—Eczematous Conjunctivitis*). In phlyctenular conjunctivitis (Plate IV., Fig. 1) one or more small, round, grey or yellow nodules, slightly raised above the surface, are seen on the bulbar conjunctiva, generally at or near the limbus; they rarely occur on the palpebral conjunctiva. The disease is very frequently complicated with muco-purulent conjunctivitis, in which case the whole conjunctiva is intensely reddened. In pure phlyctenular conjunctivitis the congestion of the vessels is limited to the area around the phlyctens.

The disease is most frequent in children from five or six to ten or twelve years of age, but not very young children; it is rarely seen in adults. The children often have enlarged lymphatic glands in the neck, &c., or other signs of tubercle; on the other hand, every sign of tubercle may not infrequently be lacking: the children, however, are seldom robust. The first attack often follows an exanthem, especially measles. Rhinitis and adenoids are frequently present; signs of congenital syphilis may be found.

Phlyctens, as the name suggests (φλύκταινα, a bleb), at first much resemble blebs: it is doubtful, however, whether there is a true vesicular stage. They may be so small as to be seen with difficulty, but they usually measure about 1 mm. in diameter, occasionally reaching a diameter of 3 mm. or 4 mm. The larger ones are yellow, and have been described as pustules. In the later stages the epithelium over the surface is often destroyed, small ulcers being formed. When this occurs on the conjunctiva proper it is of little moment, since healing takes place rapidly without the formation of a scar. When it occurs on the cornea, as is very frequently the case, it is much more serious (*vide* p. 221).

Very frequently the skin of the lids and cheeks shows an eczematous condition, and eczema will be found not uncommon, if searched for, in other parts of the body, especially in the scalp. This fact has led the condition to be regarded by some as an ocular manifestation of eczema. The disease has indeed been regarded as an exanthem. It is probable that in most cases the eczema of the lids and face is secondary to the continual irritation of the skin induced by the overflow of tears and the rubbing of the wet surface with the hands.

Pathology throws some light on the disorder, though it by

no means settles the causation   A simple phlycten shows in section a triangular area of intense infiltration, the apex of the triangle being towards the deeper layers   The sub-epithelial adenoid layer normally contains a few mononuclear lymphocytes, but in the phlycten they are very numerous and closely packed together   The epithelium is intact, and it is doubtful if a vesicular stage has ever been observed

If there is a considerable amount of conjunctivitis of the muco purulent type, not only are lymphocytes present, but there are also many polymorphonuclear leucocytes, both in the sub epithelial tissues and among the epithelial cells   In such cases the epithelium is quickly desquamated

If a bacteriological examination is made, many of the organisms of muco purulent conjunctivitis may be found   In the pure phlyctenular cases only staphylococci are found in abundance   Now staphylococci are not so common as might be expected in the normal conjunctival sac , it has, therefore, been concluded that the disease is due to staphylococcic infection   If staphylococci are rubbed into a healthy or excoriated conjunctiva a transitory redness occurs and rapidly passes off   Phlyctens have never been produced in this manner   The nearest approach to the artificial produc tion of phlyctens has been by injecting cultures of tubercle bacilli in which the organisms have been killed into the veins of rabbits   It is doubtful if the infiltrates were real phlyctens in these experiments, but it is certain that the administration of tuberculin has not infrequently been followed by an attack of phlyctenular conjunctivitis in the human subject   On the other hand, the superficial position of the lesions and the analogy to other ulcerative conditions of the cornea favour the view that the disease is ectogenous in origin the morbid agent being at present unknown   Tubercle bacilli have never been found in the phlyctens

Evidence has accumulated of recent years that phlyc tenular conjunctivitis is an allergic condition, i e , an abnormal sensitivity to substances which are usually innocuous , e g , pollen (hay fever), drugs, &c (v p 182) and bacterial proteins   To the last group belong chronic allergic conjunctivitis, phlyctenular disease, and possibly spring catarrh (q v)   In phlyctenular conjunctivitis it is probable that tuberculous toxins are the irritating factor (von Szili, Weekers), but it is possible that other proteins may be involved   This view is supported by the frequent occurrence of eczema of the skin in phlyctenular disease

The irritation of the eye leads the child to rub it vigorously The lacrymation and rubbing cause an ecze matous condition of the skin, in which the staphylococci normally present flourish and increase   These are rubbed into the eye, increasing the irritation, without being primarily responsible for the disease   Other organisms are also rubbed in if they happen to be present , they find a suitable nidus in the debilitated conjunctiva, and an acute muco purulent conjunctivitis is superimposed upon the phlyctenular disease

Simple phlyctenular conjunctivitis is attended with few symptoms   There is some discomfort and irritation associated with reflex lacrymation   If there is no muco purulent com plication and if the cornea is not involved there is little or no photophobia

Complications, however, are the rule, partly because the behaviour of the child conduces to them, partly because the favourite situation for the phlyctens is near the cornea   Here they are often astride the limbus   It has already been men tioned that the epithelium of the cornea is closely associated anatomically and developmentally with the conjunctiva   It is not surprising therefore that there is a great tendency for the superficial layers of the cornea to suffer when the conjunc tiva is disordered and this is seen *par excellence* in phlyc tenular ophthalmia   The special corneal complications will be considered later (*vide* p 221)   In all such cases photophobia is increased, muco-purulent discharge is often present, and photophobia is intense

The term photophobia ($\phi\tilde{\omega}\varsigma$, light , $\phi o\beta o\varsigma$, fear , dread of light) is a misnomer   It is the term applied to the blepharo spasm which is set up by the conjunctival, or more probably corneal, irritation and which becomes greatly increased on the slightest attempt to separate the lids, especially if the attempt is made in bright light   This blepharospasm is not abolished in the dark , it is abolished by thorough application of cocaine, though this is difficult to effect   It must be con cluded therefore that it is a reflex due to afferent impulses travelling along the fifth nerve, not along the optic nerve   It has been said that light acts as the stimulus to the fifth nerve endings in the cornea   There is little evidence to prove— though it is not disproved—that light can stimulate the fifth nerve endings , at the same time the fact that sneezing is often produced by exposure to very bright light may be adduced as a positive argument   It is far more probable that " photo-

phobia " is due to a vicious circle of such a nature that movement of the lid over a spot denuded of epithelium, where the nerve endings are laid bare, causes reflex contraction of the orbicularis, this increases the irritation, increasing in turn the blepharospasm This view is supported by the fact that there is little or no photophobia until muco purulent conjunctivitis has supervened, when denudation of epithelium occurs, exposing the nerve endings, which are further irritated by toxins

Photophobia is more intense when the phlyctens are near the cornea, than when at a distance It varies rather with their number than their size, and is extreme if they are so numerous as to form a ring round the cornea

Temporary blindness has been observed occasionally in children after long continued blepharospasm It passes off in two or three weeks and is probably functional, induced primarily by the desire not to see and facilitated by the effect of prolonged pressure upon the globe by the tightly closed lids

Severe blepharospasm makes the greatest care in the first examination imperative The condition of the cornea is in all cases and at all costs to be placed beyond doubt It facilitates investigation if the lids are gently separated and a drop of 2 per cent cocaine instilled The child is left for 5 to 10 minutes and the eyes are then examined with all the precautions previously described (p 88)

Phlyctenular conjunctivitis shows a very marked tendency to recur at intervals during the age period which is specially concerned These recurrences usually take place when some intercurrent malady or defective condition in the patient's surroundings leads to lowering of vitality.

Treatment Simple phlyctenular conjunctivitis is usually readily amenable to treatment, which must be local and general

Local treatment consists in bathing the eyes frequently *with hot boric or sublimate lotion yellow oxide of mercury* ointment gr iv—viii to ʒ i, is used a piece the size of a hemp seed being placed within the lids three times a day, the eye is gently massaged by a finger placed upon the upper lid, moving the lid upon the globe

Ointments are best applied on a glass rod The child is placed upon its back on a couch and an assistant holds the arms against the body, keeping the legs still by pressure with the elbows The surgeon separates the lids with two fingers

of one hand and places the end of the glass rod carrying the ointment between the separated lids Keeping the rod in position the lids are allowed to close upon its end and it is then withdrawn by carrying it outwards towards the temple The other end of the rod and the surgeon's other hand are used for the other eye

If there is any corneal complication or evidence of its imminence, atropine, gr iv to $\mathfrak{Z}$ i, is combined with the yellow ointment

Very frequently the soddening of the skin with tears and the wrinkling of the skin through blepharospasm cause excoriations (rhagadæ) at the outer canthus They much increase the blepharospasm and should always be looked for and treated They are very troublesome unless attacked by cauterisation They should be touched with the sharp point of the solid silver nitrate or the mitigated silver stick

An efficient substitute for the yellow oxide which has fallen into undeserved disuse is finely powdered calomel dusted into the eye best from a camel's hair brush which is not allowed to touch the eye It often produces a remarkable improvement in intractable cases but it must not be employed if iodides are being given internally under these circumstances the unstable and extremely irritating mercurous iodide is formed in the conjunctival sac

The blepharospasm is best treated when severe in the following manner The child's face should be plunged in cold water and the mouth and nose kept under water until he struggles for breath, this is repeated three or four times—daily if necessary The treatment is useless if not carried out ruthlessly but no other method is so efficacious It is not uncommon for a single application to render further treatment of the blepharospasm unnecessary

The eyes are never to be bandaged unless corneal ulceration is so severe as to assume the preponderant *rôle* A shade covering both eyes and extending well over the temples should be ordered Smoked glasses may be substituted but they should not be tightly fitting goggles which will become soiled with the discharge and are cleaned with difficulty

General treatment is never to be neglected otherwise recurrence is inevitable Fresh air is the best tonic and the children should be kept out of doors as much as possible the windows of living and sleeping rooms must be kept open Sun or artificial light baths have proved very good and cold or sea baths are useful Good food with a plentiful supply of

fresh vegetables, is indicated   A calomel purge should initiate the general régime

Cod liver oil and maltine are given in the cool weather and throughout the year if well tolerated   They may be alternated with preparations containing vitamins A and D   Phosphates and iodide of iron form substitutes or supplementary tonics   Calcium in the form of calcium gluconate ($\mathfrak{Z}$ i ter in die) has been advocated

General régime must be continued for a prolonged period in order to prevent recurrence, and, in any case, phlyctenular ophthalma should be regarded as a sign of debility which requires attention (*vide* p 223)

Simple Chronic Conjunctivitis occurs as a continuation of simple acute conjunctivitis, sometimes in spite of orthodox treatment, especially in the " gouty " type of patient   It is frequent when the cause of irritation is continuous—smoke, dust, heat   bad air, late hours, abuse of alcohol, and so on. A very common cause is the chronic reflex irritation induced by errors of refraction, overuse of the eye in bright electric light, &c   Permanent irritation from concretions (*vide* p 188) in the palpebral conjunctiva, misplaced lashes, dacryocystitis, chronic rhinitis, &c, must be remembered and as far as possible eliminated   Unilateral chronic conjunctivitis should suggest the presence of a foreign body retained in the fornix, or inflammation of the lacrymal sac   It is often necessary to make a thorough and systematic investigation of the local and general conditions before the cause can be found   It is not infrequently associated with chronic intranasal trouble   The disease is too frequently regarded as trivial   but it is a source of great discomfort to the patient, who is duly grateful for permanent relief

Burning and grittiness are complained of, *especially in the evening* when the eyes often become red   Difficulty in keeping the eyes open is a common symptom   The lids may or may not be stuck together on waking

The discharge is slight, most frequently subnormal, so that the edges of the lids feel hot and dry

The eyes may look quite normal on first examination   When the lower lid is pulled down the posterior conjunctival vessels are seen to be congested, and the surface of the mucous membrane is sticky   The palpebral conjunctiva, upper and lower, may be congested, with velvety papilliform roughness   Occasionally it is succulent and fleshy

Treatment consists in eliminating the cause and restoring the conjunctiva to its normal condition   Errors of refraction

and chronic nasal catarrh are perhaps most likely to be forgotten, they should be sought out as a matter of routine When heat is a prominent ætiological factor, *e g*, in cooks, spectrum blue glasses may be ordered, since th y cut off the heat rays to a large extent The treatment of the special local conditions mentioned above will be discussed in their proper place A gouty tendency should be treated by an appropriate régime

Local treatment consists essentially in diminishing conges tion and restoring the conjunctiva to its normal suppleness and secretory activity It must be remembered that the condition is largely one of lack of tone due to defective response to prolonged irritation A stimulating treatment is therefore indicated, and is supplied by astringent applications, which not only act by relieving the congestion, but also promote a more healthy lymph flow and glandular secretion

In mild cases weak astringent lotions suffice, *e g*, boric lotion with zinc sulphate gr 1—11 to ʒ 1, alum lotion, gr 1v to ʒ 1 &c They should be used two or three times a day, not immediately before going to bed Adrenaline has a transient effect in diminishing redness and itching Boric acid ointment or sterile vaseline should be applied to the margins of the lids at bed time In recalcitrant cases mercury oxycamide (1 in 5 000) may be used, followed by zinc sulphate lotion at a later stage

In severer cases a preliminary painting with silver nitrate solution is indicated, repeated once or twice a week if necessary, or the milder protargol (5—10 per cent) may be used Silver preparations should not be ordered for application at home, since prolonged use may lead to staining of the conjunctiva (argyrosis)

Atropine, which is always resorted to by the inexperienced in intractable diseases of the eye, does much more harm than good It causes great inconvenience from paralysis of accom modation and has little effect upon the conjunctiva, such as it has being deleterious Apart from this it is extremely dangerous in elderly patients, who are specially liable to chronic conjunctivitis In them more than in others, there is grave danger that atropine may induce an acute attack of glaucoma, a disaster which it is impossible to overrate

In the more severe cases of chronic conjunctivitis there is often an abnormal amount of secretion from the Meibomian glands. This should be squeezed out of the glands by pressure on the lid with the thumb against a spatula laid upon the conjunctival surface

Angular Conjunctivitis (Syn —Diplobacillary Conjunctivitis) is one of the few forms in which a specific organism causes a typical clinical picture In it the reddening of the conjunctiva is limited almost exclusively to the inter marginal strip, especially at the inner and outer canthi, and to the bulbar conjunctiva in the same neighbourhood Besides the conjunctivitis there is also excoriation of the skin at the inner and outer angles, which may be very slight a mere scurfiness, but is nearly always present After a few cases have been seen the typical picture is very easy to recognise but the condition is not always typical There is discomfort, with slight muco purulent discharge blinking is often complained of Not infrequently there is nasal catarrh and diplobacilli are found in the nasal secretion If untreated the condition becomes chronic and may give rise to definite blepharitis Clear shallow corneal ulcers may occur but are rare They are usually marginal, but may be central and associated with hypopyon (*vide* p 214) A single attack does not confer immunity and relapses are not uncommon

Pathology The disease is due to the Morax Axenfeld diplobacillus (Fig 105) The bacilli consist of pairs of large, thick rods placed end to end They stain well with basic stains, are decolourised by Gram and are easily recognised in films There is an incubation period of four days The diplobacilli are strongly resistant to drying They have been found in the nasal tract of healthy persons and

Fig 105—Diplobacilli (× 1000)

are often present in the nasal discharge in cases of angular conjunctivitis

Treatment Diplobacillary conjunctivitis responds readily to zinc salts These may be applied in the form of boric lotion with zinc sulphate gr ii to ʒ i, or as drops, preferably the former It is not known how zinc salts act in these cases for the diplobacillus will grow in cultures containing them Boric, zinc oxide, or ichthyol (2—5 per cent) ointment is applied to the lids at night

Follicular Conjunctivitis occurs frequently in children and young adults, both eyes being affected It is characterised by the formation of small round or oval translucent bodies, 1 mm or 2 mm in diameter, in the lower fornix (Plate IV Fig 2), they are less commonly seen in the upper fornix, especially near the outer and inner canthi, never on the plica semilunaris or bulbar conjunctiva They are raised above the surface, are often arranged in parallel rows, and consist of localised aggregations of lymphocytes—follicles, sometimes wrongly termed granulations—in the sub epithelial adenoid layer

Microscopically follicles are indistinguishable from the solitary lymph patches in the intestine, and often also from the follicles of trachoma (q v) They do not occur in the normal conjunctiva in man The conjunctiva is not reddened or swollen They persist for an indefinite time, causing few symptoms, and disappear without leaving any trace, such as scarring (cf Trachoma)

Follicular conjunctivitis is usually due to overcrowding and living in badly ventilated rooms, especially schoolrooms but also occurs among better class school children Isolated follicles may occur in the outer part of the lower fornix in any chronic conjunctivitis of long standing They may be due to over use of atropine or eserine (vide p 184) The children are seldom robust and adenoid vegetations in the throat, which are of a similar nature, are often present The disease is probably not contagious, and never develops into trachoma as has been held by some observers

The symptoms are slight, consisting chiefly of slight irritation of the eyes, worse in bright lights and after near work

Treatment Follicular conjunctivitis seldom requires local treatment A weak astringent lotion may be ordered and yellow oxide of mercury introduced within the lids once or twice a day If the follicles are very large painting with silver nitrate solution will do good, single follicles may be touched with the alum pencil Atropine, if in use, should be stopped or replaced by an equivalent mydriatic (vide p 184)

Special attention should be directed to the refraction, and any errors corrected

The nose and throat should be investigated and the general health and surroundings put upon a sound basis

Trachoma (Syn —Granular Conjunctivitis) is a much more serious form of folliculosis, which is responsible for the blinding of enormous numbers of people in places where it is endemic Both eyes are almost always affected It may be stated at

once that in England it is a rare disease except where large numbers of Irish or aliens are herded together

In making a diagnosis the relative frequency of various forms of disease should always be borne in mind It is a truism, but it is often disregarded, that an unusual type of case is less likely to be a rare disease than an unfamiliar manifestation of a common one A better class child with follicles in the conjunctiva is most unlikely to be a case of trachoma, whereas, if the child goes to school in the East End of London, where there are large numbers of trachomatous aliens, the distinction of follicular conjunctivitis from trachoma becomes a matter of great difficulty

The changes met with in the conjunctiva in trachoma are of two types, which are often present simultaneously The *papillary* type is not specially characteristic, it is usually a more definite form of the papillary enlargement and congestion which is met with in other severe forms of conjunctivitis The conjunctiva covering the upper tarsus is most affected, and appears red and velvety This condition may pass into one with more uniform jelly like thickening Only in the comparatively infrequent cases in which no follicles can be seen will the true disease pass wholly unsuspected

Fig 106 — Trachoma. (After Nettleship), showing trachoma follicles and scar in typical position parallel with the edge of the lid

The *follicular* type (Fig 106) manifests itself in the presence of follicles in the conjunctiva When small they cannot be distinguished from the follicles of follicular conjunctivitis, and microscopical examination shows that they are fundamentally identical They often, however, assume a size and appearance which is seldom or never seen in follicular conjunctivitis, but they differ most in having a characteristic distribution The large follicles may be 5 mm or 6 mm in diameter They are translucent and look like grains of boiled sago ("sago grains")

The follicles usually commence in the lower fornix, but in most cases they quickly appear in the upper also Unlike what obtains in follicular conjunctivitis, they are not limited to the fornices They often form a row along the upper margin of the upper tarsus, whence they invade the palpebral conjunctiva, appearing upon the tarsal surface, though they

are less numerous in this situation They are common about the caruncle and may be seen on the plica semilunaris Follicles do not occur on the upper tarsal conjunctiva in folli cular conjunctivitis except at the inner and outer angles They are very rare on the bulbar conjunctiva but when seen here they are pathognomonic of trachoma

The disease is very chronic and leads to much irritation, photophobia lacrymation, &c , with some muco purulent discharge In certain districts abroad trachoma is endemic and a very acute form is observed It is very doubtful if *true acute trachoma is ever seen in England* what usually passes for it is of quite different origin It is due to the lowering of resistance of the trachomatous conjunctiva whereby it becomes specially liable to intercurrent attacks of other forms of acute conjunctivitis This is facilitated by the irritation which leads to rubbing of the eyes so that contamination is readily brought about The so called acute trachoma met with in England is therefore chronic trachoma upon which an acute muco purulent or purulent conjunctivitis has been engrafted Even in Egypt the acute symptoms are most often caused by the Morax Axenfeld diplobacillus, the Koch Weeks bacillus or the gonococcus (MacCallan)

Trachoma is an extremely contagious disease Pathological anatomy reveals nothing characteristic there is lymphocytic infiltration of the whole of the adenoid layer of the parts of the conjunctiva affected Special aggregations of lymphocytes, without a definite capsule form follicles which are generally indistinguishable from those of follicular conjunctivitis In late stages and large follicles the stroma and cells tend to become hyaline and gelatinous, sometimes the surface becomes broken and the contents are extruded into the con junctival sac In other cases a fibrous capsule forms around the follicles which thus become isolated more and more fibrous tissue is laid down, giving rise to cicatricial bands such as are never formed in follicular conjunctivitis, and are very characteristic

Noguchi isolated a *bacillus granulosus* from the trachoma of Red Indians which when inoculated into monkeys produces follicles in the conjunctiva very similar to the follicles of human trachoma it is probably not the cause of the disease The ' trachoma bodies ' described some years ago are not pathognomonic since such cell inclusions are very common in virus diseases of plants and animals They suggest strongly that the disease is due to a virus, or Rickettsia especially as

they are transmissible to lice (Cuénod and Nataf). Inclusion bodies in scrapings from the conjunctiva are therefore of some diagnostic importance.

Trachoma is endemic in many parts of the world, *e.g.*, Russia, Poland, East Prussia, parts of Austria-Hungary, Egypt, Syria, Persia, China and Japan It shows a predilection for certain races, *e.g.*, Irish, Jews, but it is not a racial disease ; the predilection depends upon the mode of life of the individuals. Extended observation militates against the view that any race is exempt, though it is uncommon among negroes.

The disease flourishes among people who are crowded together in unhealthy rooms—in armies, navies, asylums, workhouses, schools, &c.—wherever the lower classes are herded together. Children and debilitated adults are most susceptible, but the robust are not exempt It is commoner in low-lying, damp districts.

The disease is spread by transference of conjunctival secretion by means of fingers, towels, &c The presence of much discharge, whether of true trachomatous origin or due to intercurrent conjunctivitis, increases the liability to contagion. On the other hand, scrupulous cleanliness suffices to prevent the extension of the disease to healthy subjects.

Trachoma in the early stages may be easily mistaken for a simple chronic conjunctivitis This error will be avoided if it be made an invariable rule in all cases of con junctivitis to evert the upper lids and examine the upper fornices (*vide* p. 80).

Fig 107 —Trachomatous pannus (After Nettleship)

Complications. While trachoma very rarely affects the bulbar conjunctiva, it not infrequently attacks the cornea.

Trachomatous pannus is a lymphoid infiltration, with vascularisation, of the margin of the cornea, usually limited to the upper half (Fig. 107), but tending to spread towards the centre and to involve the whole cornea. The upper part of the margin of the cornea becomes cloudy, and minute superficial vessels, springing from the corneal loops, grow inwards towards the centre. The haziness and vascularisation increase until the upper half of the cornea is affected. The vessels are all superficial (*vide* p 90), and microscopic examination has

shown that they lie at first between Bowman's membrane and the epithelium   They carry in with them a small amount of granulation tissue   In later stages Bowman's membrane disappears and the superficial layers of the substantia propria become involved

In progressive pannus the vessels are mostly parallel to each other and directed vertically downwards, anastomosing little   They extend to a level which forms a horizontal line, and beyond this line there is a narrow strip of infiltration and haze   In regressive pannus, on the other hand, the vessels extend a short distance beyond the area which is infiltrated and hazy · this difference is useful in estimating the results of treatment

In more severe cases the vascularisation is not limited to the upper part, but superficial vessels grow in from all sides and the whole cornea becomes vascularised and opaque

Pannus is not due to the rough upper lid rubbing upon the cornea   This is doubtless a predisposing factor, but in many conditions in which the lids are rough from some other cause pannus does not occur   It is not due to continuity, since the bulbar conjunctiva from the limbus to the fornix is unaffected   It is induced by contiguity, probably by direct infection and this part of the cornea is most affected because it is covered by the lid both day and night

It may resolve completely, leaving the cornea quite clear, but only in cases treated early, when the vessels have not yet destroyed Bowman's membrane   In other cases a permanent opacity results   Occasionally the corneal substance becomes weakened so that the cornea bulges under normal intraocular pressure and ectasia follows (keratectasia)

Corneal Ulcers are commonest at the advancing edge of the pannus   They are shallow, little infiltrated, and very irritable, causing much lacrymation and photophobia   Indolent central ulcers may form, or there may be ulcers in any part of the cornea, but especially over the pannous area

Sequelæ Apart from the results of pannus and corneal ulceration the most malign effects of trachoma are caused by distortions of the lids   A peculiar drooping of the upper lids is very characteristic (*trachomatous ptosis*) It gives a sleepy appearance to the patient   There is always some scarring (Fig 106), and when this is extensive the shape and position of the lids, especially the upper, are altered   Pressure on the everted upper lid will cause the appearance of white bloodless areas which may be mistaken for trachomatous scarring   They are easily distinguished by relieving the pressure

Through the great swelling of the conjunctiva the lids may be turned outwards (ectropion) In the late stages the follicles invade the tarsus, causing softening and absorption of the dense fibrous tissue , through the later contraction of the newformed scar tissue the lids may be turned inwards (entropion), causing the lashes to rub against the cornea (trichiasis), &c. (See Chap XXXI)

Treatment If there is much discharge the case must first be treated with a view to diminishing it and reducing congestion   The lids should be painted once daily with silver nitrate solution , sublimate lotion should be thoroughly used three or more times a day, and boric ointment applied to the edges of the lids at bed time

In a few days the conjunctivitis will be much less, and an attempt must be made to get rid of the follicles In relatively slight cases this is best effected by scouring the conjunctiva with a smooth crystal of copper sulphate The crystal is fixed in a wooden holder and is pointed at the end The lids are everted, and the point of the copper stick is pushed well up into the upper fornix and moved from one side to the other, the lid being lifted away from the globe by the stick during the manœuvre so as to avoid touching the cornea The stick is then rubbed firmly over the whole of the palpebral conjunctiva

The application of the copper stick is very painful, especially during the first few applications Pantocain may be previously instilled, but it does not prevent the intense smarting It is important to start with the upper fornix, since this is most affected and most difficult to reach , if it is not done first blepharospasm and the struggles of the patient will make it impossible afterwards It is useless to apply copper too gently , it must be firmly rubbed into the conjunctiva Some of the sulphate dissolves in the tears, and should be mopped up with a pad of dry wool, since it is very irritating to the cornea Pannus is no contra indication to the use of the copper stick, but quite the reverse, copper sulphate applied to the lids is the best treatment for pannus The pannus itself is not treated directly at all On the other hand, corneal ulceration of any kind or degree is an absolute contra indication , in these cases, even if pannus is present, reliance must be placed on silver nitrate until the ulcers are healed Unfortunately silver has little specific influence over the trachomatous process whereas that of copper is undoubted

The copper stick must be applied once daily, otherwise the case is certain to run on indefinitely Sublimate lotion

is ordered for home use as before   Active treatment should be carried out for many weeks and should be continued for several weeks after apparent cure   In the later stages copper sulphate drops (gr 1 ad ℥ 1) or copper sulphate (1 per cent) or copper citrate (10 per cent) ointment may be used

Sulphanilamide (*vide* p 693) taken by the mouth in full doses maintaining a concentration of 5 mgm per 100 c c of blood for ten to fourteen days has been found beneficial   In some cases blepharospasm has been relieved within twenty four hours and inclusion bodies have disappeared in three days the bulbar conjunctiva becomes white in a few days pannus is reduced and corneal ulcers may be healed in a week   Relatively avascular lymph follicles however persist and are absorbed slowly

In most cases of trachoma the treatment advised will suffice to bring about that condition of amelioration which is usually described as cure   Relapses are common, occurring sooner or later according to the length and assiduity of treatment

In severer cases more drastic remedies must be employed   Probably the best of the stronger applications is a concentrated solution of perchloride of mercury in glycerine   It has been used as strong as 4 per cent , in these circumstances it acts as a caustic   It is painted on the fornix and everted lids   This treatment is almost unbearably painful and is followed by intense reaction the conjunctiva and lids becoming enormously swollen   The pain lasts for several hours gradually diminishing in intensity   Ice or lint wrung out in iced water should be applied to the lids immediately after the application   There is no doubt that much benefit is derived from the treatment

Fig 108 —
Graddy's fo ceps

The follicles may also be destroyed by touching them with a solid stick of carbon dioxide snow   Care must be taken to allow the tissues to thaw before the everted lid is replaced   X rays and radium have also been used but do not give better results than the ordinary treatment

When the follicles are numerous and very prominent the treatment is shortened by attacking them mechanically This may be done by various forms of scarification or expression In performing any operation upon trachomatous patients protective goggles must be worn by the surgeon and the immediate attendants

The conjunctiva is first thoroughly anæsthetized Scarification may be performed by a knife, needle, sharp spoon or stiff toothbrush The follicles may also be destroyed by the galvano cautery or by electrolysis

In *expression* one of the many forms of expressor is used—*e g* Graddy's forceps (Fig 108) Knapp's roller forceps (Fig 109) The upper lid is everted, and one limb of the forceps is pushed up into the fornix, the other being laid upon the palpebral conjunctiva The two limbs are then pressed together with moderate force and are drawn in a horizontal direction from one end of the fold to the other The fold of the fornix should in this manner be thoroughly mangled, and all the follicles squeezed out Some recommend the immediate application of silver nitrate or sublimate solution (1 in 2000) but it is best simply to apply cold compresses, since there is always considerable reaction

If the follicles in the upper fornix are very large and closely packed it is well to commence treatment by excising the fornix There is always a redundance of tissue here, and no evil results ensue The upper lid is everted doubly (*vide* p 81) so as to expose the retro tarsal fold completely A silk suture is then passed through the fold at each end By dragging on the sutures the whole fold is drawn out It is *then excised with scissors* If the tarsal plate is much diseased or distorted it also may be excised

Pannus requires no special treatment but if it fails to respond a *peritomy* may be performed In this operation a collar of conjunctiva, 5 mm broad, is excised round the corneal margin The raw surface of the sclera should be seared with the galvano cautery, the object being to destroy the vessels and prevent

Fig 109 — Knapp's roller forceps.

their reformation Corneal ulcers must be treated on general principles (*vide* p 204)

Hygienic treatment must be carried out so far as practicable The influx of aliens into the East End of London made trachoma a serious menace to our own population the enforcement of the Aliens Immigration Acts has greatly reduced the prevalence of the disease in England

Trachoma, then known as Egyptian ophthalmia, was spread far and wide in Europe by the French armies during the Napoleonic wars Brilliant success attended the efforts to deal with trachoma among the Chinese labourers during the Great War, and not only was there no dissemination of the disease, but most of the cases were alleviated or cured

Inclusion Blennorrhœa has been regarded as a modified form of trachoma but this is improbable It is an acute follicular conjunctivitis caused by a virus disease, as shown by the presence of inclusion bodies and by the transference of the disease by the filtrates of emulsified conjunctival scrapings through a fine Berkefeld filter It is the cause of *swimming bath conjunctivitis* but is also found in inmates of schools, asylums &c Its occurrence in cases of ophthalmia neonatorum and the presence of inclusion bodies in urethral and vaginal discharges suggests a genital origin

Tubercle of the Conjunctiva is rare it nearly always produces ulceration Conjunctival ulceration should always suggest either the presence of an imbedded foreign body or a tuberculous or syphilitic lesion

Fig 110 —Tubercle of the conjunctiva
(After Eyre)

Tubercle occurs in several forms (1) small miliary ulcers usually on the palpebral conjunctiva, (2) granules on the palpebral conjunctiva resembling trachoma follicles (Fig 110), (3) gelatinous cockscomb like excrescences on the fornices , (4) polypoid pedunculated outgrowths , (5) a solitary nodule near the limbus which may

become infected with pyogenic organisms and ulcerate Occasionally tubercle attacks the bulbar conjunctiva elsewhere, and the conjunctiva may be affected by extension of lupus from the face These cases must be distinguished from those with secondary extension of tubercle from within the eyeball (*vide* pp 216, 340) Infection is generally endogenous

The preauricular gland is often enlarged and may suppurate The disease is chronic, and the ulcers are indolent The patients are usually young, and often free from clinical signs of active tuberculous disease elsewhere in the body There is little doubt that the lesion may be the primary seat of tubercle, the bacilli being inoculated into minute abrasions, which are probably always present in the conjunctiva, caused by dust There is little pain or irritation unless the ulceration is extensive

It is not improbable that the second type is frequently mistaken for trachoma, and it is possible that it is cured by the treatment founded on the wrong diagnosis I have seen cockscomb tubercle in the lower fornix associated with tuberculous disease of the lacrymal sac in a child

Pathology Scrapings may show tubercle bacilli Sections show typical giant-cell systems In doubtful cases inoculation experiments should be made If a piece of tuberculous tissue is introduced into the anterior chamber of a rabbit's eye a typical tuberculous iritis will ensue in two or three weeks Intraperitoneal inoculation of guinea pigs is more satisfactory Dermal tests or injections of tuberculin may be tried

Treatment The disease should be eradicated, more especially as being often the primary focus The affected conjunctiva should be excised, or if this is not feasible, thoroughly scraped and cauterised

Injections of tuberculin have given encouraging results, and subconjunctival injections of 2 per cent guaiacol cacodylate may be employed The application of 50 per cent solution of lactic acid has been advocated Generalised ultra violet ray therapy is certainly beneficial

Extension to the globe is probably rare If prolonged treatment fails and the disease spreads it may be necessary to excise the eye

Syphilis manifests itself rarely in the conjunctiva in the form of a primary chancre, which is less indurated than the ordinary genital chancre, or gummatous ulceration In the former case it may be due to the removal of a foreign body with the tongue Ulceration of the palpebral or still more of

the bulbar conjunctiva is always suggestive of the condition
Scrapings should be taken and examined for spirochætes, and
the Wassermann test should be applied (*vide* p 620)   A
primary chancre of the palpebral conjunctiva may be wrongly
diagnosed and treated as a chalazion (*vide* p 622)

Conjunctivitis caused by Drugs (Atropine Irritation, &c) and
Irritants   Some people are particularly susceptible to atropine,
and more rarely to eserine and other drugs, locally applied to
the conjunctiva   The lids become swollen, tense, and red, in
fact erysipelatous   Examination of the conjunctiva will often
show follicles, and even rarely a membrane   The cause is
obscure, but seems to be allied to anaphylaxis   sometimes the
condition seems to be due to a special solution or brand of the
drug, owing to some impurity   Workers with chrysophanic
acid suffer from conjunctival irritation, and prolonged internal
administration of arsenic causes the same effect   The dust of
teak wood is particularly irritating to the conjunctiva   Con
junctivitis is also caused in some people by contact with horses
or cats, or certain flowers, especially *Primula obconica*

A chip of aniline pencil in the eye causes considerable
irritation and unsightly staining

Malingerers sometimes induce conjunctivitis by the insertion
of tobacco, ipecacuanha powder, &c   into the eyes   The
irritation is most marked in the lower fornix, and usually the
right eye is affected in right handed people

Treatment   In atropine irritation the drug should be avoided
If a mydriatic is imperative, some other should be substituted,
e g , duboisine sulphate, 0 5 per cent , or scopolamine hydro
bromide, 0 25 per cent to 0 5 per cent , or hyoscine, 0 5 per
cent , may be used but toxic symptoms sometimes o cur
Subconjunctival injection of mydricain (*vide* p 692) may
be used with impunity in these cases   Atropine irritation
has been cured in some cases by instilling adrenaline (1 in
1,000) drops, moistening the skin of the lids with this solution,
and subsequent application of zinc oxide ointment (Wolff)
The conjunctiva soon recovers after cessation of the cause,
but astringent lotions accelerate the cure

Aniline dye staining can be removed by washing out with
weak alcohol solution and instillation of weak glycerine drops
(Werner)

Action of Caustics   See p 430

Poison gases used in warfare include lacrymatory gases, phos
gene, mustard gas, and other secret agents

The *lacrymatory gases* include h S K (ethyliodoacetate), B B C (bromobenzylcyanide) and C A P (chloroacetophenone) They cause immediate irritation of the eyes, profuse lacrymation and blepharospasm The conjunctiva is injected and swollen, but there is no involvement of the cornea The symptoms disappear in a few hours, and the eyes respond well to lavage with bland lotions Chlorine, phosgene, arsenical compounds and ' smokes ' also cause conjunctival irritation

Mustard gas (dichlorethyl sulphide) usually produces ocular symptoms after a latent period of from 6 to 8 hours, and is effective when very dilute (1 in 10 000 000 in air) The severity of the attack depends upon the concentration and the length of time of exposure The lesions are slowly progressive, and there is marked delay in healing, analogous to X ray burns In mode rately severe cases the conjunctiva is congested and swollen in the interpalpebral area Functional blepharospasm may persist after all inflammatory signs have disappeared, and fear of blind ness may delay convalescence In more severe cases the inter palpebral zone of conjunctiva is white from coagulated exudate and chemotic conjunctiva bulges forwards from the fornices The lids are swollen and stuck together by discharge The cornea is stippled (' orange skin ' cornea), with œdematous and roughened epithelium, and corneal sensation is diminished , or the interpalpebral strip may necrose The pupil is constricted Secondary infection may lead to ulceration, hypopyon and pan ophthalmitis Chest complications and an anxiety neurosis may delay convalescence Severe cases (about 10 per cent) require 2 to 4 months' treatment before returning to duty, and quite a number of them break down with recurrent corneal ulceration several years later

The *treatment* of conjunctivitis caused by lacrymatory gases is irrigation with bland lotions—normal saline, boric or sodium bicarbonate (2 per cent) The eyes should not be bandaged, but dark glasses used

In mustard gas injuries the lids should be gently separated, the cornea inspected and the patient assured that he is not blind The eyes are irrigated with warm sodium bicarbonate lotion and cod liver oil drops instilled dark glasses are worn and vaseline ointment is applied to the lid margins at night If the cornea is hazy, or stains with fluorescein, atropine (1 per cent) should be instilled twice daily, with the same precautions as described for hypopyon ulcer (*vide* p 214) Sulphonamides may be given by the mouth if there is severe secondary infection Tarsorraphy may be necessary in some cases It is very important to combat the neurasthenia by appropriate means At a later stage contact glasses afford protection to the cornea and aid vision

Spring Catarrh (*Syn—Vernal Conjunctivitis*) This is a recurrent conjunctivitis occurring with the onset of hot weather and therefore rather a summer than spring complaint It is found in young people, nearly always boys, associated with the usual symptoms of mild conjunctivitis Burning, itching some photophobia, and lacrymation are the chief symptoms Both eyes are affected In the cooler months the condition subsides and gives no trouble, but recurs with the return of heat The disease is met with among all classes, is sporadic and non-contagious It has been attributed on insufficient grounds to the action of the actinic rays of the spectrum It is more probably an allergic condition, as indicated by the accompanying eosinophilia

Two types of objective signs are met with (1) the palpebral form, (2) the bulbar form both may be combined, but this is relatively rare The palpebral form is easily recognised if typical One vertical section view the upper lid the palpebral conjunctiva is seen to be hypertrophied and mapped out into polygonal raised areas not unlike cobble stones (Fig
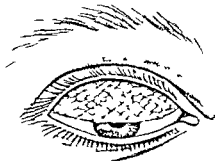
Fig 111 —The palpebral form of spring catarrh

The colour is bluish white, like milk and this appearance is seen also over the lower palpebral conjunctiva

The flat topped nodules are hard, and consist chiefly of dense fibrous tissue but the epithelium over them is thickened giving rise to the milky hue In vertical section they resemble circumvallate papillæ Eosinophilia leucocytes are present in them in great numbers and are found in the secretion.

The palpebral form cannot be mistaken if typical but it may resemble trachoma The type of patient, the milky hue, the freedom of the fornix from implication and the characteristic recurrence in hot weather will usually prevent mistake

The bulbar form is less characteristic In it there is a wall of thickening at the limbus, more gelatinous in appearance and also milky It may be mistaken for phlyctenular conjunctivitis

In both forms the lesions persist during the cold months, though they are less marked

Serious complications never supervene and the ultimate prognosis is good, though recurrences may persist for several years Occasionally a peculiar corneal opacity, resembling arcus senilis in having a clear zone between it and the limbus, is left, and some thickening and discoloration of the conjunctiva may remain

Treatment is purely symptomatic   Well fitting goggles with tinted glass should be worn   The irritation is best relieved by very weak acetic acid, gt 1 to 3 vi   Adrenaline gives temporary relief   Gentle massage with the upper lid after application of yellow oxide of mercury ointment or 1—2 per cent guaiacol ointment is beneficial   Astringents are harmful   boroglyceride has been recommended, with arsenic internally   The application of 10 milligrams of unscreened radium (β rays), held by a layer of varnish in the shallow trough of a monel metal spatula shaped for insertion under the upper lid, at monthly intervals during February, March and April, seems to be of value in preventing an attack, but does not cure the disease   Excision of the nodules, sometimes advised, seems to be useless   The general health should be attended to, and adenoids and enlarged tonsils, if present, removed

Ophthalmia nodosa is a nodular conjunctivitis which may be mistaken for tubercle—pseudo tuberculous disease of the conjunctiva   It is due to the irritation of the hairs of certain cater pillars, and therefore always commences in the late summer months   Small semitranslucent, reddish, or yellowish grey nodules are formed in the conjunctiva and sometimes in the iris   On microscopical examination hairs surrounded by giant cells and lymphocytes are found

Treatment   The nodules in the conjunctiva should be excised   Otherwise the condition is treated on general principles

Parinaud's Conjunctivitis may be mistaken for tubercle or trachoma   Usually one eye only is affected   Granulations occur on the tarsal conjunctiva or fornices, and the preauricular and submaxillary glands are enlarged and may suppurate   The disease commences with slight constitutional disturbance and may last for months   It has been attributed to bovine tubercle and to a leptothrix (Verhoeff)

Pemphigus of the conjunctiva is a rare but very serious disease   Vesicles occur, but more commonly greyish white membraneous patches   Progressive cicatrisation of the conjunctiva follows, leading eventually to *essential shrinking of the conjunctiva,* with consequent opacification of the cornea from malnutrition   Vesicles may be found in the nose, mouth and pharynx, but rarely in the skin   Treatment, such as transplantation of mucous

membrane is unavailing   Contact glasses applied with parolein give some relief and improve vision

Electric Light Ophthalmia (Photophthalmia)   The ultra violet rays of the electric light may cause extreme burning pain, lacrymation, photophobia, blepharospasm and swelling of the palpebral conjunctiva and retrotarsal folds   There is always a latent period of four or five hours between the expo sure and the onset of symptoms   The condition is generally caused by the bright flash of a short circuit, but may result from exposure to a naked arc light, as has happened, for instance, in cinema studios   It is rarely due to exposure to enclosed arc or other lights since the glass globe absorbs the most deleterious of the ultra violet rays   Eosinophile leu cocytes are increased in the secretion

Treatment   Cold compresses, dark glasses, and astringent lotions

Snow Blindness   The cause and symptoms of snow blind ness are the same as of electric light ophthalmia, viz, expo sure to ultra violet rays, especially from 311 $\mu\mu$ to 290 $\mu\mu$, an unusually large percentage of which is reflected from snow surfaces   Smoked or orange tinted glasses should be used as a prophylactic measure, and they are most efficacious when made with Crookes's glass (*vide* p 148)   The treatment is the same as for electric light ophthalmia

DEGENERATIVE CHANGES IN THE CONJUNCTIVA

Concretions   (*Syn — "Lithiasis"*)   Concretions occur as minute hard yellow spots in the palpebral conjunctiva   They are due to the accumulation of epithelial cells and inspissated mucus in depressions which are called Henle's glands   They never become calcareous, so the term is a misnomer, but they are so hard that when they project from the surface they scratch the cornea and give the sensation of a foreign body in the eye   They are common in elderly people   There is no reason to attribute them to gout, for uric acid deposits have been observed in the palpebral conjunctiva of gouty patients   Concretions should be removed with a sharp needle

Pinguecula is a triangular patch on the conjunctiva, found usually in elderly people especially those exposed to dust wind, and so on   It occurs in the direction of the palpebral aperture, the apex of the triangle being away from the cornea

It affects the nasal side first then the temporal. It is yellow in colour and looks like fat whence the name (pinguecula fat). It is not due to fat but to hyaline degeneration of the connective tissue and an excessive development of yellow elastic fibrous tissue. It is particularly conspicuous when the eye is inflamed since the conjunctiva remains relatively free from congestion. mistakes in diagnosis may then occur. It requires no treatment but may be removed if the disfigurement is great.

Pterygium (πτερύξ a wing). This is a peculiar encroachment of the conjunctiva on the cornea (Fig 112). It is triangular in shape and when single is always upon the nasal side. when double the temporal one has developed later. It
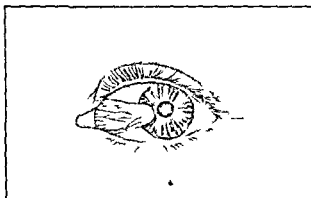
Fig 11º.—Pterygium

is derived from pinguecula (Fuchs). It must be carefully distinguished from *pseudo pterygium* which is due to the tip of a fold of chemotic conjunctiva becoming adherent to an ulcer within the corneal margin. It may occur at any part of the cornea. The conjunctiva then forms a bridge over the limbus and a fine probe can always be passed beneath it which is not possible with a true pterygium.

The apex of the pterygium is usually blunt. there is no ulcer in the cornea beyond it as formerly described. but there are often small opacities. In the early stage the pterygium is thick and vascular. it advances over the cornea and may reach the pupillary area and interfere with vision. When it ceases to grow it becomes thin and pale but never disappears.

The true pterygium is a single layer of conjunctiva adherent in its whole length to the sclerotic and cornea though only loosely, except at the apex. The area of adhesion is always

smaller than its breadth, so that there are folds at the upper and lower borders

Pterygium is not due to a fold of conjunctiva being dragged across the cornea by a progressive ulcer, as was once taught It is probably due to malnutrition of the cornea, resulting from the pinguecula, and prolonged irritation Granulation tissue grows in under the epithelium, destroying Bowman's membrane When it ceases to progress dense fibrous tissue is formed

Pterygium is rare in England, but is common in dry climates with sandy soils, e g, parts of Australia, South Africa, Texas &c It was common in soldiers during the Boer War, and it is not infrequently seen in sailors

Treatment Pterygium is best left alone unless it is progressing rapidly towards the pupillary area, or is very disfiguring The latter reason is not of much weight, since it cannot be removed without leaving a scar

The apex of the pterygium may be destroyed by diathermy Removal is effected by seizing the neck, near the corneal margin, with fixation forceps, raising it, and shaving or dissecting the apex from the cornea Care must be taken not to go too deep The pterygium is then freed from the sclerotic for about half the distance towards the canthus Two converging incisions with scissors separate the apex and greater part of the body The conjunctiva is then freed from the sclerotic above and below so as to admit of the two edges being sutured together

Pterygium sometimes recurs after removal This may be only apparent owing to vascularisation of the denuded area If it actually re forms and extends towards the pupillary area, the apex should be turned down under the bulbar conjunctiva and sutured in this position (McReynolds)

SYMPTOMATIC CONDITIONS

Subconjunctival Ecchymosis, due to the rupture of small vessels, frequently occurs It may be the result of direct injury, or, more commonly, occurs spontaneously Very minute ecchymoses, or possibly thromboses, are seen in severe conjunctivitis, especially pneumococcic Larger ones accompany severe straining especially in old people, e g, on lifting heavy weights, vomiting, &c In these circumstances they indicate a weakness of the vessel walls, and should be regarded as a danger signal Other signs of arteriosclerosis should be sought in the fundus oculi and elsewhere, and, if found, warn-

ing of the possibility of cerebral hæmorrhage given, with appropriate instructions for its avoidance Very frequently no such signs can be discovered, and the condition, though unsightly, is trivial Subconjunctival ecchymoses are not infrequently seen in children with whooping cough , as a rule they need arouse no anxiety, but retinal hæmorrhages and hyphæma also occur in association with them, as well as cerebral hæmorrhage

More serious are the large subconjunctival ecchymoses which sometimes follow blows or falls on the head They may then be due to extravasation of blood along the floor of the orbit, the result of a fractured base In fractures of the sphenoid the blood appears later on the temporal side than elsewhere Hæmorrhage also results from severe or pro longed pressure on the thorax and abdomen, as in persons squeezed in a crowd

Subconjunctival hæmorrhages may occur in scurvy, pur pura, malaria, and so on

The importance of subconjunctival hæmorrhage is always symptomatic since the eye itself is never endangered

Treatment The blood becomes absorbed in from one to three weeks without treatment Boric lotion is usually ordered as a placebo Dionin may be used to accelerate absorption in young patients, but should not be employed in elderly subjects with arteriosclerosis

Chemosis, or œdema of the conjunctiva, may occur (1) in acute inflammations , (2) in cases of obstruction to t lymph flow , (3) in abnormal blood conditions

In the first group of cases the inflammation may be in ne conjunctiva, e g , gonorrhœal conjunctivitis, or within the eye ball, as in panophthalmitis, hypopyon ulcer It is also found in acute glaucoma The inflammation may be in the accessory structures of the eye, e g , a stye, a parasitic bite on the lid, dacryocystitis, periostitis, orbital cellulitis, cerebro spinal meningitis The chemosis of dionin is probably due to a specific irritation of the conjunctival vessel walls

In the second group the pressure of an orbital tumour may so interfere with the lymph and blood streams as to produce chemosis, and it is found in pulsating exophthalmos

To the third group belong Bright's disease and the anæmias It is sometimes due to urticaria or angioneurotic œdema Recurrent chemosis is sometimes associated with menstruation, and it has been observed in trigeminal neuralgia and migraine

Xerosis (*Syn —Xerophthalmia*) (ξηρος, dry) is a dry, lustreless condition of the conjunctiva which occurs in two groups of cases (1) as a sequel of local ocular affection, (2) associated with general disease

The first type is a cicatricial degeneration of the conjunctiva —(a) following trachoma, burns, pemphigus, diphtheria, &c, commencing in isolated spots, ultimately involving the whole conjunctiva and cornea, (b) following exposure, due to ectropion or proptosis, whereby the eye is not properly covered by the lids As the result of the rare affection of the conjunctiva with pemphigus the cicatricial contraction of the conjunctiva may be extreme and progressive, a sort of keloid condition being induced (*essential shrinking of the conjunctiva*) the lids may then be quite adherent to the globe, the cornea being opaque like skin (*vide* p 187)

In the other group of cases xerosis occurs in a mild form, found in children usually boys, accompanied by night blindness (Chap XIX) and characterised by small triangular white patches on the outer and inner sides of the cornea, covered by a material resembling dried foam, which is not wetted by the tears (Bitot's spots) The cases usually occur during the summer months, and the children are not conspicuously ill nourished A similar mild form, also associated with night blindness (*vide* p 412), is met with in adults in some countries e g, India but seldom if ever in England A severe form is found in marasmic children, associated with keratomalacia (*vide* p 224) and necrosis of the cornea

Pathology The chief changes are in the epithelium, which becomes epidermoid i e, exactly like that of skin, with granular and horny layers The foamy spots are due to horny epithelium which becomes cast off into the conjunctival sac and accumulates in the lower fornix Owing to this change the epithelium ceases to secrete mucus It becomes dry, a certain amount of vicarious activity is set up in the Meibomian glands (Chap XXXI), which cover the surface with their fatty secretion The watery tears then fail to moisten the conjunctiva The so-called xerosis bacilli, which are pseudo diphtheria bacilli, grow profusely under these conditions, but they have no causal relationship and are of no importance

Xerophthalmia, and the associated night blindness is a deficiency disease due to absence of fat soluble vitamin A in the diet This vitamin is contained in cod liver oil milk, and butter

It is to be noted that xerosis has nothing to do with any

failure of function on the part of the lacrymal apparatus.
The conjunctiva can be quite efficiently moistened by its own
secretions alone   If the lacrymal gland is extirpated xerosis
does not follow   If on the other hand the secretory activity
of the membrane itself is impaired xerosis follows, in spite of
normal or increased lacrymal secretion   The tears of rabbits
fed on vitamin A deficient diets are deficient in lysozyme
(Findlay), thus explaining the susceptibility to local bacterial
invasion

Treatment   Xerosis is a symptom, and its treatment must
therefore be purely symptomatic   Local treatment consists
in relieving the dryness with parolein, olive oil, milk, weak
alkaline solutions, &c   smoked glasses should be worn

In xerophthalmia restoration of normal nutrition by admini
stration of vitamin A and other measures is all important,
though in marasmic cases the patients have often gone too far

Argyrosis is the staining of the conjunctiva from prolonged
application of silver salts (nitrate, protargol, &c) for the
treatment of chronic conjunctivitis, and especially trachoma
The conjunctiva, particularly the lower fornix, is stained
deep brown   The staining is due to the impregnation of the
elastic fibres in the membrane and vessel walls with reduced
metallic silver   The condition is very difficult to get rid of,
but subconjunctival injections of potassium iodide (m iij —
iv. of a 30 per cent solution) and internal administration of
hexamin (urotropin) over a prolonged period have been
advocated   Subconjunctival injection (0 3 c c) of 2 parts
of 2 per cent potassium ferricyanide with 1 part of 12 per cent
sodium thiosulphate appears to be much more efficacious   a
plantinum needle must be used to avoid staining with iron

CYSTS AND TUMOURS

The only common cysts found in the conjunctiva are due *to*
dilatation of lymph spaces   When small these often form rows
of little cysts on the bulbar conjunctiva (*lymphangiectasis*)
Occasionally single, though multilocular, cysts occur (*lymphan-
gioma*)   Larger retention cysts of Krause's accessory lacrymal
glands occur in the upper fornix (Chap XXXI)   Subcon-
junctival cysticercus and hydatid are rare in England   Non
parasitic cysts require simple removal of the anterior walls
Epithelial implantation cysts occur rarely after injuries or opera-
tions, e g, tenotomy, and may burrow into the cornea

Tumours of the conjunctiva have all a tendency to be poly
owing to the perpetual movements of the globe and lids

Papillomata occur at the inner canthus and in the fornices   In the latter position they may be mistaken for the cockscomb type of tubercle, but the individual leaflets may be separated by a probe   They also occur sometimes at the limbus in old people and are then liable to become malignant   They should be removed

Simple Granulomata, generally polypoid, often grow from tenotomy wounds or the sites of foreign bodies   They consist of exuberant granulation tissue   They are common in empty sockets after excision, and at the site of chalazions which
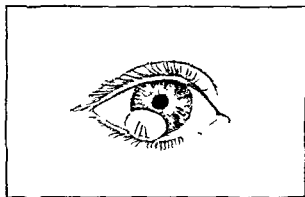
Fig 113 —Dermoid of the conjunctiva in a somewhat unusual situation   Note the hairs

have been insufficiently scraped (Chap XXXI)   They should be removed by scissors

Fibromata also generally polypoid, occur in sockets   They may be soft or hard, and require simple removal

Nævi or *congenital* moles are not uncommon   They are white gelatinous or pigmented nodules situated by preference at the limbus or near the plica semilunaris   They have the same structure as in the skin—groups often alveolar, of ' nævus cells" in close connection with the epithelium   They *are congenital* and tend to grow at puberty, rarely becoming malignant   They may be excised   Pigmentation at the limbus occurs normally in dark races, and patches in this situation are not uncommon in people with dark complexions

Dermoids are lenticular yellow tumours, usually astride the corneal margin most commonly at the outer side (Fig 113)   They are often wrongly called dermoids of the cornea   Not infrequently there is a notch in the upper lid corresponding with the position of the tumour   They consist of skin in an abnormal situation, with epidermoid epithelium, hairs sebaceous glands, &c

They are congenital and tend to grow at puberty, the hairs also grow and often cause irritation Dermoids should be dissected off the globe if troublesome though their removal does not produce much improvement in appearance, as the site of attachment to the cornea remains densely opaque

Dermo lipomata or *fibro fatty tumours* are congenital tumours found at the outer canthus in babies They consist of fibrous tissue and fat, sometimes with dermoid tissue on the surface They are not encapsuled The main mass should be removed, but it will be found that the fat is continuous with that of the orbit care must be taken not to injure the extrinsic
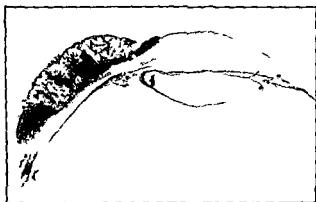
Fig 114 —Epithelioma of the conjunctiva from a section (× 6)

muscles Dermo lipomata may be associated with accessory auricles and other congenital defects

Sarcoma is rare It occurs at the limbus, is usually pigmented, and most of the patients have been old Sarcomata spread over the surface of the globe, but rarely penetrate it Recurrence and metastasis occur as elsewhere in the body They may be alveolar —derived from nævi—or round or spindle celled They must be removed as freely as possible and examined microscopically On the slightest sign of recurrence the eye must be excised, and if recurrence again takes place the orbit must be exenterated or deep X ray therapy adopted A diffuse spreading pigmentation of the conjunctiva occurs rarely in elderly people, and has been known to give rise to metastatic sarcomatous tumours It should always be viewed with grave suspicion

Epithelioma (Syn —Squamous-celled Carcinoma) occurs par excellence where one kind of epithelium passes into another, hence in the eye chiefly at the limbus (Fig 114), and at the edges of the lids Papillomata in old people often take on malignant

7—2

proliferation.   Like sarcomata, epitheliomata spread over the
surface and into the fornices, rarely penetrating the globe. They
have the characteristic structure.   The treatment is the same as
for sarcoma · it is well in both cases to cauterise the base by
diathermy or the actual cautery after the first removal

Rodent Ulcer (Syn —Basal-celled Carcinoma) may invade the
conjunctiva from the lids (*vide* p 643).

CHAPTER XI

Diseases of the Cornea

The special importance of diseases of the cornea depends upon the fact that they often leave permanent opacities which seriously lower the visual acuity, while the complications which not infrequently attend them may lead to the loss of the eye

INFLAMMATION OF THE CORNEA (KERATITIS)

Inflammation of the cornea may be purulent or non purulent An immense amount of research has been devoted to inflammation of the cornea from the earliest investigations of Bowman (1849) onwards, and much of our knowledge of inflammation in general is derived from these researches

Purulent Keratitis, Ulceration of the Cornea Purulent keratitis is nearly always exogenous, i e, it is due to pyogenic organisms which invade the cornea from without The first line of defence is the epithelium It has been pointed out that the only organisms which are known to be able to invade normal epithelium are the gonococcus and the diphtheria bacillus, but many other bacteria are capable of producing ulceration, notably the pneumococcus

When we remember the exposed position of the cornea it is not surprising that minute abrasions are extremely common They are probably of everyday occurrence, but other factors have also to be reckoned with Pathogenic organisms of high virulence are not always present in the conjunctival sac, and if they are, as is often the case, the resistance of the normal tissues has to be taken into account It is too often forgotten that normal tissues with a healthy blood supply and lymph flow are well armed against any but the most virulent invaders Even with these prolonged contact is usually necessary

Apart from actual abrasions many causes of diminished resistance of the epithelium are met with Such are drying, as in xerosis, necrosis due to deficient nutrition, as in keratomalacia, desquamation as the result of œdema or neuroparalytic keratitis If cocaine is instilled too freely, especially

if the lids are not kept closed in the intervals, the epithelium becomes dull and is finally thrown off   Hence this drug is to be used with caution and only under supervision , it should seldom be given in lotions for use at home

Malnutrition affects not only the epithelium but also the whole cornea   In badly nourished corneæ ulceration is apt to be deep, leading to early perforation, and also extensive, resulting in widespread necrosis   Such septic ulcers, due to the attack of ordinary pyogenic organisms, occur after injuries in asthenic conditions, in keratomalacia, lagophthalmia, &c   Corneal ulcers are much commoner in the lower orders, doubt less owing to the defective resistance of the tissues and the more frequent exposure to injury

In the commonest form of suppurative keratitis—the corneal ulcer—there is localised necrosis in the most anterior layers of the cornea   The sequestrum is partly disintegrated and cast off into the conjunctival sac, and partly adheres to the surface of the ulcer   Usually the epithelium is destroyed and cast off over an area considerably larger than the ulcer itself, and the same applies to Bowman's membrane   The epithe lium, however, rapidly advances towards the ulcer, grows over its edge, and even over the slough or pus which forms the floor

The ulcer is usually saucer shaped, and the walls project above the normal surface of the cornea (Fig 115), owing to imbibition of fluid by the corneal lamellæ, which causes them to swell   The spaces between the lamellæ are packed with leucocytes for some distance around the ulcer appearing as a grey zone of infiltration   This is the progressive stage

A line of demarcation forms as in necrosis elsewhere in the body   The toxins are most concentrated near the centre where there are most organisms   A wall of polymorphonuclear leucocytes forms a second line of defence   At a certain dis tance the tissues are protected , here the leucocytes are not paralysed or killed by toxins, but exert their digestive func tions, macerating and dissolving the necrotic tissues   When the dead material has been thrown off the ulcer is somewhat larger, but the cloudiness has disappeared, the floor and edges are smooth and transparent, and the regressive stage is reached

Meanwhile vascularisation has been going on (Plate V Fig 1)   Minute superficial vessels grow in from the limbus near the ulcer   They supply the pabulum to restore the loss of substance   they also supply protective substances—anti

bodies—and therefore play an important *rôle* in combating bacterial infection   Sometimes they are so exuberant as to overstep the limits of utility, *e g*, in fascicular ulcer (*vide* p 221)

When the ulcer has become vascularised, everything is prepared for cicatrisation, which is carried out exactly as in other connective tissues   The fixed connective tissue cells, here the corneal corpuscles, divide and form masses of nucleated spindle shaped cells, over which the epithelium grows and is lifted to its normal level   The nuclei and vessels gradually disappear, and a mass of fibrous tissue is formed The fibres are not arranged regularly like the normal lamellæ, so that they refract the light in various directions   the scar is, therefore, more or less opaque according to its thickness   If it is very large and dense some of the larger vessels persist permanently , the smaller ones disappear   Bowman's mem-

Fig 115 —Vertical section of a corneal ulcer showing infiltration of the substantia propria.

brane is never regenerated, and if it has been destroyed, as is the case in all but very superficial abrasions, some degree of permanent opacity remains

During the progressive stage there is lacrymation photophobia, and pain, owing to the exposure of the fibrils of the ophthalmic division of the fifth nerve   Some of the toxins elaborated by the bacteria diffuse through the cornea into the anterior chamber, just as atropine does when instilled into the conjunctival sac   Here they exert an irritative effect upon the vessels of the iris and ciliary body, so that hyperæmia of the iris, with or without definite ciliary injection, occurs   The irritation may be so great that leucocytosis takes place, and polymorphonuclear leucocytes are poured out by the vessels of the iris and ciliary processes   They pass into the aqueous and gravitate to the bottom of the anterior chamber, where they form an *hypopyon* (Plate VI, Fig 2   Fig 131)

There are several important facts about hypopyon which must be borne in mind   The pus cells do not come from the

cornea, as was once thought This is proved by the following facts (1) Descemet's membrane is impermeable to leucocytes, though fluids readily pass through it , (2) the cells sometimes contain pigment granules, obviously derived from the uveal tract , (3) if the ulcer has not perforated, the hypopyon is sterile The last fact is of the greatest importance, both theoretically and practically It shows that the leucocytosis is due to toxins, not to actual invasion of bacteria, which, indeed, are as incapable of passing through the intact Descemet's membrane as are leucocytes It accounts for the ease and rapidity with which hypopyon is often absorbed it may develop in an hour or two, rapidly disappear, and as readily reappear Such hypopyons are very fluid, always moving to the lowest part of the anterior chamber if the position of the patient's head is changed The fact that the hypopyon is sterile has great practical importance—it is unnecessary to remove the pus as is the rule in all other parts of the body , if the ulcerative process can be stopped the hypopyon will be absorbed

The hypopyon may be so small that it is scarcely visible, being hidden behind the rim of sclera which overlaps the cornea It may reach half way up the iris, having a flat upper surface in accordance with the laws of gravity It may fill the anterior chamber, wholly obscuring the iris The larger hypopyons are usually less fluid, owing to the formation of a fibrinous network which imprisons the leucocytes in its meshes Such hypopyons are much less readily absorbed and it may be necessary or advisable to evacuate them

The scar tissue which replaces the destroyed portions of the cornea usually fills in the gap exactly, so that the surface is level If it is thin the resulting opacity is slight and is called a *nebula* (Plate V , Fig 1), if rather more dense it is some times called a *macula* if very dense and white it is called a *leucoma* Old central leucomata sometimes show a horizontal pigmented line in the palpebral aperture, the nature of which is obscure A thin diffuse nebula covering the pupillary area interferes more with vision than a strictly localised dense leucoma, so long as the latter does not block the whole pupil lary area The reason is that the leucoma stops all the light which falls upon it (Fig 116) whereas the nebula refracts it irregularly, allowing many of the rays to fall upon the retina where they blur the image formed by the regularly refracted rays An opacity does not necessarily prevent the light from being focussed upon the retina immediately behind it Thus,

PLATE V

Fig. 1.—Nebulæ

2.—Phlyctenular Tumo.s
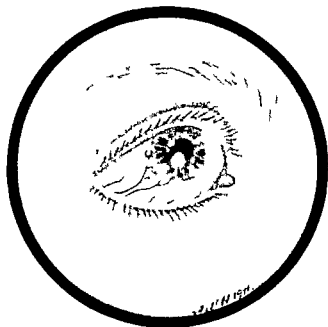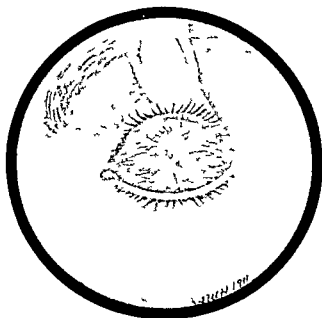
PLATE VII.
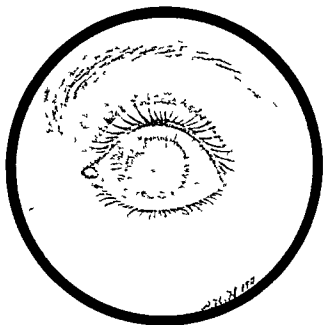
Fig. 1 Interstitial keratitis
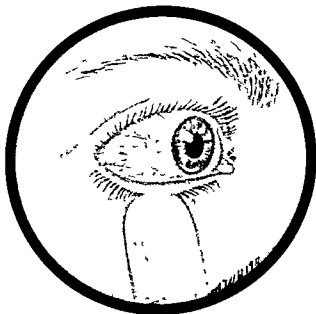
Fig. 2.—Episcleritis

a central opacity of the cornea will not prevent the focussing of an object upon the macular region, for the rays passing through the clear peripheral parts of the cornea will be refracted towards the macula, only those rays being cut off which are incident to the corneal surface at the opaque region. There is thus a loss of brightness rather than of definition, though definition will also be impaired by the superposition of a diffuse entoptic image of the opacity upon the clear image of the external object

When Bowman's membrane has been destroyed the opacity is permanent, but even then it tends to clear more or less. The younger the patient the more clearing may be anticipated The deeper the cicatrix the less it clears , perforating wounds remain permanently opaque   This fact is well illustrated by
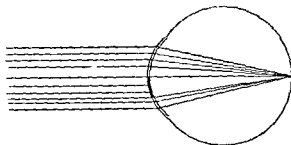
Fig 116 —Optical effect of a corneal opacity

the punctures made by discission needles in needling cataract , they remain as grey spots in the cornea throughout life Vascularisation plays a part in the clearing of corneal opacities, as is shown by the fact that they clear first in the immediate vicinity of the vessels

Extremely thin cicatrices may be almost or quite transparent   In them there is often deficient scar tissue formed so that the surface is flattened or even indented   Such corneal *facets* can only be seen by carefully examining the corneal reflex (*vide* p 86), but they cause considerable defect of visual acuity

From the same cause—deficiency of scar tissue—the cornea may be markedly thinner at the site of the ulcer than elsewhere   The scar may then bulge above the surface, owing to ineffectual resistance to the normal intraocular pressure. As the cicatrix becomes consolidated the bulging may disappear, or it may remain permanently as an *ectatic cicatrix* (keratectasia from ulcer).

Some ulcers, especially those due to the pneumococcus and

septic organisms, extend rapidly in depth   There is then grave danger of perforation   The whole thickness of the cornea except Descemet's membrane and a few corneal lamellæ may be destroyed   Descemet's membrane like other elastic membranes, offers great resistance to inflammatory processes   It is, however, unable alone to support the intraocular pressure   it therefore becomes protruded through the ulcer, appearing upon the surface as a transparent vesicle, which is called a *keratocele*   This may persist, surrounded by a white cicatricial ring, or it may eventually rupture

Perforation and its effects   When an ulcer perforates the aqueous suddenly escapes and the intraocular pressure sinks to zero, i e , to the atmospheric pressure   The iris and lens are driven forwards into contact with the back of the cornea

The effect of perforation upon the nutrition of the cornea is good   owing to the diminution of intraocular pressure the diffusion of lymph through the cornea is facilitated   Ulceration usually ceases, pain is alleviated and cicatrisation proceeds rapidly   The complications which attend perforation are, however, of extreme danger to sight and even to the preservation of the eye   These complications vary according to the position and size of the perforation

Usually the perforation takes place opposite some part of the iris, which therefore lines the aperture when the aqueous escapes   The iris becomes gummed down to the opening by lymph, which gradually organises, and an *anterior synechia* is formed   The blocking of the perforation with iris allows the anterior chamber to be re formed, fresh aqueous being rapidly secreted

The aqueous often escapes very quickly owing to some sudden exertion on the part of the patient, e g , coughing, sneezing straining at stool or spasm of the orbicularis   Any such sudden exertion causes a rise in general blood pressure, which at once manifests itself by a rise in intraocular pressure   The weak floor of the ulcer is unable to support the sudden strain and gives way   In such a case especially if the perforation is large a portion of the iris is carried not only into the opening but through it, and a *prolapse of iris* is produced   The prolapse may not include the pupillary margin, in which case it is hemispherical , or the pupillary margin may also prolapse, a tag of iris lying free upon the cornea   In either case the colour of the iris soon becomes obscured by the deposition of grey or yellow lymph upon the surface   In large

prolapses the stroma becomes thinned and the black retinal pigment epithelium is thrown into relief

Sometimes the whole cornea sloughs, with the exception of a narrow rim at the margin and *total prolapse of iris* occurs The pupil usually becomes blocked with exudate, and a false cornea is formed, consisting of iris covered by lymph

If the perforation takes place very suddenly the suspensory ligament of the lens is much stretched It may rupture partially, causing tilting or dislocation of the lens, or wholly, so that the lens may be expelled through the perforation

If prolapse of iris has occurred cicatrisation may still progress The lymph which covers the prolapse or pseudo cornea becomes organised and forms a thin layer of connective tissue over which the conjunctival or corneal epithelium rapidly grows The contraction of the bands of fibrous tissue tends to flatten the protruding prolapse or pseudo cornea It rarely however, becomes

Fig 117 —Anterior staphyloma showing also an anterior capsular (pyramidal) cataract (R. L O H Museum)

quite flat , more commonly the iris and cicatricial tissue are too weak to support the restored intraocular pressure, which is often increased, owing to the advance in position of the iris (*vide* p 280) The cicatrix tends therefore to become ectatic, and such an ectatic cicatrix in which the iris is incarcerated is called an *anterior staphyloma* (Fig 117) If the prolapse of iris is partial the resulting staphyloma will be partial , if total, a total staphyloma will ensue The bands of scar tissue on the staphyloma vary in breadth and thickness, producing a lobulated surface, hence the name (σταφυλή, a bunch of grapes)

If the perforation happens to be opposite the pupil it cannot

be covered with iris The pupil often becomes adherent to the margin, and the aperture becomes filled with exudate The anterior chamber is then re formed very slowly the lens remains long in contact with the ulcer, and permanent opacity may occur in it—*anterior capsular cataract* (Fig 117) As the anterior chamber re forms the exudate filling the opening is submitted to strain It frequently ruptures, especially if the patient is restless This process may be repeated again and again, so that the opening may become permanent—*corneal fistula*

The sudden reduction of intraocular pressure when the per .oration occurs removes support from all the intraocular blood vessels They become dilated and may rupture, *intraocular hæmorrhage* taking place The retinal vessels may rupture, causing vitreous hæmorrhage, or the choroidal, causing sub retinal or sub choroidal hæmorrhage It may be so pro fuse that the contents of the globe are extruded with the out flowing blood , indeed, in very rare cases the hæmorrhage may endanger life, for it is most likely to occur in old people with atheromatous vessels

Finally, the organisms which have caused the ulceration of the cornea may gain access to the interior of the eye as the result of perforation, the vitreous acting as an excellent culture medium *Purulent irido-cyclitis* or even *panophthalmitis* may thus be set up, a result especially prone to occur in gonorrhœal ophthalmia and in hypopyon ulcer (q 1)

Treatment of Uncomplicated Ulcers Cleanliness, heat, rest and protection are the fundamental principles of the treatment of corneal ulcers Surgical cleanliness is the principle which should regulate the use of lotions , heat is employed to prevent stasis and encourage repair , local rest is attained by the use of atropine , rest and protection from deleterious external agencies are aimed at in the use of a pad and bandage

The ordinary treatment of a simple uncomplicated ulcer is as follows The conjunctival sac is washed out carefully three or more times a day with a considerable quantity of a mild antiseptic lotion, which should be used as hot as can be borne comfortably (*vide* p 152) It acts principally by washing away secretions and necrotic material, which carry with them many of the organisms and their toxins It is impossible to apply antiseptics sufficiently strong to kill the organisms, hence it is of little importance whether weak sublimate lotion (1 in 8000) or simple boric lotion be used

After each irrigation a drop of 1 per cent atropine solution

or a small lump of 1 per cent atropine ointment is introduced between the lids

A protective pad and bandage are then applied It consists of a pad of sterile gamgee tissue, or a layer of cyanide gauze covered by a pad of cotton wool, kept in place by a bandage, firmly but tightly applied A simple tie bandage suffices This is of sufficient length to pass round the head and tie behind It passes obliquely above the sound eye, over the ulcerated eye and under the ear of the side of the affected eye, where the bandage is given a single turn the ends are tied just above the occipital protuberance

This treatment suffices for mild cases

In more severe cases hot bathings (*vide* p 692) should be applied in the intervals between bathing with lotion, which should be done more frequently—every three or four hours The compresses should be made of large round pads of plain or boric lint, on one surface of which gutta percha tissue is sewn The compresses are placed in a cloth and immersed in boiling water , by keeping the ends of the cloth out of the water and turning them in opposite directions the excess of the water is wrung out without scalding the fingers The compress is applied as hot as can be borne It is at once covered with a large pad of hot cotton wool, and bandaged into position

Atropine has a twofold function in the treatment of corneal ulcers In the first place it keeps the eye at rest by paralysing the intrinsic muscles both the sphincter iridis and ciliary muscle In the second place it prevents most of the dangerous results of iritis (*vide* p 258) Corneal ulcers are always accompanied by more or less iridic and ciliary hyperæmia, and actual inflammation often occurs

Eserine has been recommended instead of atropine in the treatment of some ulcers It has been held that prolapse is less likely to occur when a peripheral ulcer perforates if the pupil is contracted This is a fallacy Even with complete dilatation under atropine the pupil at once contracts when the aqueous escapes The objections to eserine are that it prevents rest by keeping the sphincter iridis and ciliary muscle in a state of tonic contraction that it irritates the iris and tends to increase iritis, with consequently greater risk of the formation of posterior synechiæ, and that it causes discomfort or even pain in the eye It is never to be used for a simple ulcer, though it may have beneficial effects in special chronic types (*vide* p 223)

Any contributory cause for ulceration must of course receive

attention Prominent among such causes are conjunctival conditions and general malnutrition Thus, the ulcers associated with trachomatous pannus will not heal if the lids are neglected (*vide* p 178)

In purulent conjunctivitis and trachoma the lids should be painted with silver nitrate, even during the progressive stage The copper stick must not be used in trachoma, owing to the irritative effect upon the cornea The presence of much conjunctival discharge is a contraindication to the use of a bandage the benefit derived from it is more than counteracted by the retention of secretions (*vide* p 153) It must be replaced by a shade

To restrain children from touching their bandages a cylinder of stout corrugated cardboard may be applied around the
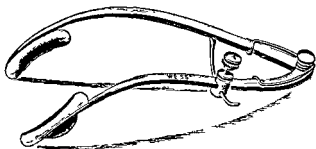
FIG 118 —Lang s speculum This form is preferable to the ordinary type as it keeps the lashes out of the field of operation

arm, reaching a little beyond the elbow, thus preventing flexion

In debilitated adults or old people and marasmic children the building up of the constitution by good food, fresh air, and tonics is often more important than the treatment of the local condition

When cicatrisation is complete and all irritative signs have passed off an attempt must be made to render the scar as transparent as possible The results are usually disappointing, but cicatrices clear considerably in young patients, and in many others a gratifying improvement may be noticed in the course of months or years Stimulating treatment is indicated, beginning with weak irritants and passing cautiously to stronger Insufflations of finely powdered calomel may be used first If it is well borne dilute yellow oxide of mercury ointment is employed A small lump of the ointment, gr iv

to ʒ 1, is placed in the conjunctival sac and rubbed in gently by rotatory movements of the upper lid by means of the

FULL S ZE
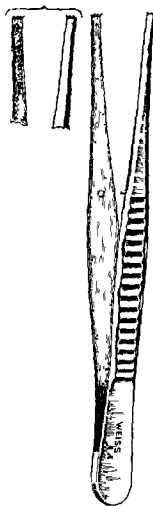
FIG 119   FIG 120

FIG 119 —Fixation forceps w th blocked ends for holding a suture
needle FIG 120 —Claw fixation forceps The latter should be used
only when a part cularly firm grip of the ep scleral tissue is
desire l e g , in operat ng upon an unsteady pat ent under local
anæsthes a

finger The massage with the lid should be employed three times a day for periods of 5 to 10 minutes If it is not resented stronger ointment up to gr xvi to ʒ 1, is   As the eye

becomes accustomed to one form of irritation it is well to change the drug from time to time The use of 2 per cent quinine bisulphate ointment twice a day has been advocated Dionin, 5 to 10 per cent , may be added to the ointment, or used in solution On application, especially for the first few times, it causes great œdema of the conjunctiva and a burning sensation The surgeon should make the first application, as the patient is often alarmed at its severity The stimulation of the blood and lymph flow induced by this drug is undoubtedly beneficial

In very intractable cases the same effect may be produced by subconjunctival injections of sodium chloride solution (2 to 10 per cent) or oxycyanide of mercury (1 in 5,000) after instillation of cocaine Five to ten minims of sterile solution are injected under the bulbar conjunctiva as far as possible behind the upper part of the limbus The pain, which may be severe is diminished by the addition of 2 per cent novocain to the solution The injection should not be repeated more than once a week

Old, degenerated, often calcareous cicatrices are best left alone, since they are liable to break down and form very dangerous ulcers, owing to the lack of resistance in the scar tissue

In some cases of superficial keratitis the scar remains permanently richly vascularised These eyes are often extremely irritable and give rise to repeated attacks of inflammation and lacrymation, which may make life a burden Though uncertain in its results peritomy (vide p 181) is the best treatment The re growth of large new vessels must be prevented, it is best effected by painting the new vessels with a very fine camel s hair brush which has been moistened and then rubbed on a silver nitrate stick, or by touching them with a diathermy needle

FULL S ZE FULL S ZE
Fig 121 Fig 122
Broad needles

If a small dense leucoma covers the pupillary area vision may be improved by an optical iridectomy (Chap XXII)

Keratoplasty, the excision of a disc of scarred cornea and its replacement by a disc of clear cornea from a human eye, is seldom successful As a rule the new tissue

rapidly becomes opaque, unless the adjacent cornea is healthy and clear, when some success may be attained

Some improvement in appearance may be obtained by tattooing dense leucomata   It is only suitable for firm smooth scars in perfectly quiet eyes, and is even then not without danger   More justifiable is the tattooing of small central nebulæ, it has the effect of cutting off the irregularly refracted rays, so that vision is improved (*vide* p 201) Tattooing with Indian ink has been replaced by impregnation with gold (brown) or platinum (black)   of these the latter is preferable   The required area is denuded of epithelium and a piece of blotting paper of the same size, soaked in platinum chloride solution, is applied   On removal a few drops of fresh hydrazine hydrate are allowed to flow over the area, which becomes black The eye is irrigated with saline, a drop of paroleın instilled, and a pad and bandage put on

Treatment of Complicated Ulcers   If per foration is imminent special means must be adopted to prevent it The patient should be confined to bed, and laxatives given

Fig 123 — keratome

Fig 124 — Desmarres paracentesis needle

Fig 125 — Spatula

It has already been pointed out that perforation improves the nutrition of the cornea   Perforation may sometimes be anticipated with advantage by *paracentesis*   By this procedure the aqueous is evacuated slowly, and the more dangerous results of perforation may be avoided   Another indication for paracentesis is extreme pain

Paracentesis may be performed through the floor of the ulcer or just inside the periphery of the cornea   When the aqueous has escaped and the inflamed iris comes in contact with the cornea the most acute pain is felt   The eye should

therefore be anæsthetised by injection of novocain into the orbit or into Tenon's capsule (vide p 466)
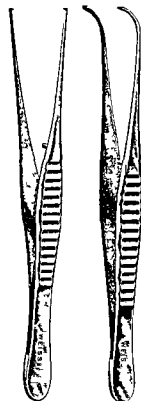
The patient lies upon his back upon the operating table The conjunctival sac is washed out with warm boric lotion or saline The speculum (Fig 118) is inserted, and the eye is fixed with fixation forceps (Figs 119, 120) by taking up a fold of conjunctiva at a convenient spot close to the corneal margin The points of the forceps should be pressed well into the conjunctiva so as to include the episcleral tissue, otherwise they are liable to tear the conjunctiva if much traction is exerted, as by an involuntary movement of the patient The eye is then pulled gently forwards The incision is made with a broad needle (Figs 121, 122), or a keratome, preferably one bent on the flat (Fig 123), or a paracentesis needle (Fig 124) If the floor of the ulcer is to be incised the point is inserted here so that the blade makes an angle of about 45° with the cornea Directly it is pushed through the floor the plane of the blade is altered so that it lies against the back of the cornea, if this is not done there is imminent danger of wounding the lens The instrument is pushed on until the incision is sufficiently long It is then very slowly withdrawn, so that the aqueous may flow off very gradually If the aqueous escapes suddenly the lens may be wounded, intraocular hæmorrhage may occur, or the iris may prolapse If the last misfortune occur the prolapse must be excised (vide p 212) If the operation is performed well, probably little aqueous will escape The spatula (Fig 125) is then applied to the edge of the wound which is nearer to the corneal margin and this lip is gently depressed The aqueous then escapes slowly and with a minimum disturbance to the eye The aqueous can be evacuated on the following day by simply opening the wound with the spatula and depressing the lip

FULL SIZE   FULL S ZE

Fig 126   Fig 127
Iris forceps straight and bent

If the incision is made near the periphery of the cornea it should be 1 to 2 mm inside the lower margin, especially if there is an hypopyon present The keratome is then entered in the plane of the iris, and its direction changed as before as soon as the point is seen to be inside the anterior chamber

In deep ulcers, such as are liable to perforate, the removal of necrotic material may be hastened by scraping the floor with a spatula or the ulcer may be cauterised (*vide* p 217) If the actual cautery is used it may be made deliberately to perforate the centre of the floor of the ulcer, so that the aqueous may escape and better conditions of nutrition be set up This procedure can only be recommended in special cases

Another procedure is to scrape the floor of the ulcer and then to cover it with a flap of conjunctiva The conjunctiva is separated from the limbus near the ulcer A second incision is made with scissors parallel to the first, so that a strip of conjunctiva rather wider than the breadth of the ulcer is separated from the globe but remains attached at the two ends This is then shifted on to the cornea so as to cover the ulcer, being retained in place by a stitch at one or both ends, thus keeping it some

Fig 1⁸ — de Wecker s scissors They should be blunt pointed for iridectomy one blade sharp pointed for indotomy

what stretched The wound in the bulbar conjunctiva may be closed by a stitch The lids are then carefully lifted over the strip so as not to displace it and the eye is bandaged

If perforation has occurred the treatment depends upon its size and situation If it is small or in the pupillary area prolapse of iris is not to be feared Rest in bed atropine, and a firmly applied bandage suffice all forced expiration— blowing the nose coughing &c —must be avoided A sneeze can often be inhibited by firm pressure with the finger upon the middle of the upper lip close to the nose If a small

perforation is over the iris, adhesion to the cornea usually *occurs* It may become detached when the anterior chamber re forms, or may be drawn out into a fine thread No special treatment is required

If prolapse of iris has occurred it should usually be excised (*vide infra*) No attempt should be made to replace the prolapse in these cases because the iris has become soiled with pus, and replacement may result in infection of the interior of the eye and panophthalmitis

Iridectomy of prolapsed iris is performed as follows Instruments required speculum, fixation forceps, two pairs of iris forceps (Figs 126, 127) de Wecker's scissors (Fig 128), iris repositor (Fig 129)

If the patient is a child or highly excitable, a general anæsthesia is used, otherwise local anæsthesia, with or without novocain, suffices (*vide* p 210) The conjunctival sac is washed out (*vide* p 152) The speculum is inserted, and the eye fixed with fixation forceps held in the left hand The iris repositor is passed into the wound between the iris and the cornea, with a view to freeing any adhesion The longer the prolapse has existed the firmer will be the adhesion of the iris to the cornea It may

Fig 129 —Iris repositor, made of silver, it can be bent to any required angle

be impossible to free it, and in this case effectual iridectomy cannot be performed Having freed the iris as much as possible, the fixation forceps are handed over to an assistant The prolapse is seized with iris forceps held in the right hand, as close to the cornea as possible, and drawn well out from the wound The second pair of iris forceps, held in the left hand, is then applied again as near the cornea as possible, and the iris drawn still further out (Capsule forceps, Fig 130) de Wecker's scissors are very good for this purpose) de Wecker's scissors are then taken in the right hand, and the iris is cut off close to the cornea If the operation has been successfully performed the stump of iris retracts into the anterior chamber and is quite free from the wound Atropine is instilled, and a pad and bandage applied

It is to be noted here that the iris is extremely ductile, it can be dragged out much farther than might be expected, and it must be dragged out as far as possible in order that

the incision may be through clean iris tissue, all the soiled part being removed   Some operators prefer to retain the fixation forceps in the left hand throughout, drawing out the iris with its forceps in the right hand   In this case the assistant cuts off the prolapse   The method has the advantage that any sudden movement of the eye may be counteracted or followed by co ordinated movements of the two hands of the same individual   Such sudden jerks have been known to drag the whole iris out of the wound, since it tears away at the thinnest part, viz , near the ciliary border   In ordinary cases the greatest danger is that of wounding the lens   A conjunctival flap may be used after excision of the prolapse (*vide* p 211)

Iridectomy of prolapsed iris is only possible within the first few days, before adhesion has become firm   It is not to be performed after this has occurred, nor in the case of very large prolapses   In the latter there is so large an opening in the cornea that a permanent fistula may result, with loss of the eye from diminished tension and shrinking

In very large prolapses there is much bulging and the base is often constricted   Every attempt should then be directed to obtain a flat cicatrix   In addition to rest in bed and the means already advised, a pressure bandage must be applied for a prolonged period   A pressure bandage differs from an ordinary protective bandage only in that the space around the eye is packed carefully with cotton wool to the level of the nose and that considerable pressure is exerted in applying the bandage

Fig 130 — Couper s capsule for ceps

Keratocele is treated first by rest and a pressure bandage   If this fails the vesicle may be punctured, and the case treated like a perforated ulcer

Fistula of the cornea is treated first like a perforated ulcer   If this treatment fails the edges of the fistula may be cauterised with the actual cautery, or a point of lunar caustic   In order that this may be done there must be some trace of an anterior chamber, otherwise the lens will be injured   A conjunctival flap may be drawn over the fistula

Commencing staphyloma should be treated by a pressure bandage If this fails a paracentesis may be done, or an iridectomy opposite the clearest part of the cornea

Hypopyon Ulcer. When an eye is injured so that an abrasion of the cornea is produced there is grave danger of infection from virulent pyogenic organisms The probabilities of this occurrence depend upon the presence of such organisms and upon the amount of resistance which the tissues possess Of all the organisms which are capable of producing deep ulceration by far the most dangerous, because the most widely spread, is the pneumococcus It is not infrequently present in the normal conjunctival sac, but it is particularly likely to be present if there is any inflammation of the lacrymal sac (dacryocystitis) The presence of dacryocystitis *is therefore a standing menace to the eye* The pneumococcus, more than any other organism, tends to give rise to hypopyon, but other pyogenic organisms may also produce this result

The substance which produces the injury may carry the infecting agent The commonest causes are scratches with the finger nail, leaves or branches, grains of corn, and minute foreign bodies, especially stone

Unless the organism be very virulent some lack of resistance on the part of the tissues must be predicated Hence hypopyon ulcers are much commonest in old people and alcoholic subjects, and in the lower rather than the upper classes The debilitating effects of hot weather are noticeable Hypopyon ulcers also occur during or after acute infectious diseases, such as measles, scarlet fever, small pox, vaccinia and so on In small pox it is not a variolous pustule upon the cornea, but it differs from the typical hypopyon ulcer

Hypopyon ulcers vary in type according to the infective agent and the age of the patient In about 70—80 per cent of all cases in adults the cause is the pneumococcus, and the ulcer is then of a very characteristic type, and has been called *ulcus serpens* from its tendency to travel over the cornea in a serpiginous fashion

The *typical ulcus serpens is a greyish white or yellowish disc* near the centre of the cornea (Plate VI , Fig 1) The opacity is greater at the edges than at the centre and is particularly well marked in one special direction A cloudy grey area, made up of fine lines, surrounds the disc, but is also more marked in the same direction The whole of the cornea may be lustreless or hazy There is a violent iritis, and the aqueous

PLATE VI
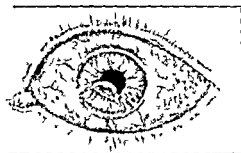
Fig 1

Fig 1 —Ulcus serpens, with crescentic infiltrated advancing border above   There was no hypopyon when the figure was drawn (from a drawing by Dr S H Habershon)
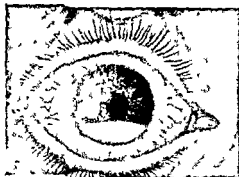
Fig 2

Fig 2 —Hypopyon ulcer
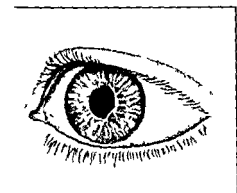
Fig 3

Fig 3 —Persistent pupillary membrane   Note the origin of the strands from the position of the minor arterial circle
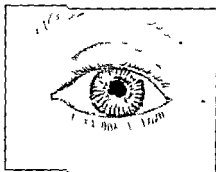
Fig 4

Fig 4 —Iritis, with irregular pupil and ring synechia causing bulging forwards of the iris ("iris bombé ")

[To

is cloudy, or there may be a definite hypopyon. The lids are slightly œdematous, and there is conjunctival and ciliary congestion. The subjective symptoms at the early stage are pain in the eye and brow and a variable amount of photophobia.

The ulcer increases in size and depth. On the side of the densest infiltration, which often looks like a yellow crescent, the tissues break down and the ulcer spreads, on the other side it may be undergoing simultaneous cicatrisation. In this manner it travels forwards. Meanwhile the hypopyon has become more evident, but it may vary in size from hour to hour (*vide* p. 200).

If left to pursue its natural course the hypopyon will increase and become fibrinous, the ulcer will perforate, usually forming a large opening through which the iris prolapses. The whole cornea, except the narrow rim nourished by the corneal loops (Plate II), may necrose, and panophthalmitis destroy the eye. In other cases an extremely dense cicatrix in which the iris is incarcerated (*adherent leucoma*) destroys sight. This may be flat or ectatic (anterior staphyloma). Sometimes the iris is bound down to the lens before perforation occurs. In such cases there are posterior synechiæ, which may be annular or total (*vide* p. 259), and the pupil may be blocked by exudates which organise into fibrous tissue (occlusion of the pupil).

Though hypopyon ulcer occurs sometimes in children, it never assumes the typical form of an ulcus serpens. In them and in some cases in adults the serpiginous character of the ulcer is not apparent, but it is distinguished by its great tendency to extend in depth, so that perforation readily occurs. On the whole, such ulcers have a milder course than the ulcus serpens, and this is especially the case in children. This is doubtless due partly to the fact that less virulent organisms are at work, especially applicable to adult cases, and partly to greater resistance of the tissues, especially applicable to children.

The milder type of hypopyon ulcer is often due to the diplobacillus of Morax or to the allied diplobacillus liquefaciens of Petit. It usually commences as a central grey infiltration, which develops into an ulcer covered by a grey membrane and surrounded by radiating grey striæ. It generally spreads in all directions, but does not show the same tendency as the pneumococcic ulcer to spread in depth. It can only be diagnosed with certainty by bacteriological examination.

Pathology　　The ulcus serpens is due to the pneumococcus, either alone or mixed with other organisms　　There is no doubt that the essential features are caused by the pneumococcus alone　　A variety of organisms—staphylococci, streptococci, gonococci, &c—have been found in atypical hypopyon ulcers　　As already stated a relatively mild form is due to the diplobacillus

Anatomically, the ulcus serpens shows at first a depressed surface covered with slough (Fig 131)　　The corneal lamellæ around and below the ulcer are separated by masses of polymorphonuclear leucocytes

In the progressive stage the infiltration is chiefly limited
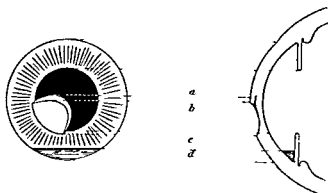
Fig 131—Diagram of hypopyon ulcer　*a—b* advancing infiltrated border　*b—c* ulcerated surface　*d* upper level of hypopyon.

to an area, wedge shaped in section, corresponding with the yellow crescent　　In other parts the edges are clean, and may be covered with epithelium　　Often there is infiltration just anterior to Descemet's membrane at a spot exactly opposite the floor of the ulcer, while the intervening lamellæ are normal This fact accounts to some extent for the great tendency to perforation, since the inflammatory process is going on as it were from both surfaces of the cornea

The hypopyon consists of polymorphonuclear leucocytes massed together in the lower angle of the anterior chamber In the later stages they are enmeshed in a network of fibrin. It has been pointed out that the leucocytes are derived from the iris and ciliary processes (*vide* p 199)

Treatment　　In all cases of hypopyon ulcer in adults treatment must be initiated at once and must be energetic　The first stage is cauterisation of the ulcer　If it is performed

skilfully it does no harm and may save the eye   It is seldom necessary in children

Cauterisation may be performed with pure carbolic acid or trichloracetic acid (10–20 per cent) or with the actual cautery, the most convenient form of the latter being the galvano-cautery (Fig 132)   In my opinion the latter method, which requires more skill, possesses no advantages and has some disadvantages   Apart from the dangers attending the use of the actual cautery, carbolic acid has the advantage of penetrating a little more deeply than it is actually applied, thus extending its antiseptic properties more widely , it acts both as a caustic and an antiseptic   No harm is done even if the acid spreads over the normal cornea   Although the parts touched become at once quite white, the normal tissues rapidly recover without detriment   The acid must not, however, touch the

HALF SIZE

FIG 132 —Ophthalmic galvano cautery, which may be worked off the main with a transformer or off a portable accumulator

conjunctiva, otherwise very acute conjunctivitis is set up and adhesion between the lids and globe may occur

Pure carbolic acid is applied as follows   The patient is seated or lying upon a couch   The ulcer is first stained with fluorescein (2 per cent), in order that its limits may be more clearly defined   The conjunctival sac is thoroughly anæsthe tized (*vide* p 465)   The surgeon stands behind or at the head With his left hand he separates the lids as in removing a foreign body, steadying the globe at the same time   The ulcer is scraped with a spatula, and together with the surrounding cornea is dried with the point of a piece of blotting paper   A wooden match, somewhat pointed, is dipped into the carbolic acid   Care is taken that the wood is thoroughly wet, but has no drop of acid hanging to it which may run over the cornea   The ulcer is then touched over the whole of its surface with the point of the match   If there is sufficient carbolic acid on the match the spot touched becomes white   Special care is taken thoroughly to cauterise the advancing edge of an ulcus serpens, *s e*, the part marked by a yellow crescent

Cauterisation with carbolic acid may be repeated two or three times at intervals of one or two days if the ulcer still progresses If this treatment, combined with the use in the intervals of mild antiseptic lotions, atropine, and hot bathings, as for less severe ulcers, does not check the progress, the actual cautery may be tried It has been recommended to heat the ulcer with the cautery without actually touching it, or hot air may be blown on to it from a rubber ball, such as is used by dental surgeons This treatment is certainly beneficial in some cases

If these means fail, and especially if the tension of the eye is raised (vide infra), yet more drastic measures must be resorted to Of these the most important is paracentesis It may be performed as already described, but in the case of hypopyon ulcers what is called Saemisch's section (though it was devised by Guthrie) offers some advantages It consists in completely dividing the ulcer from one side to the other, the ends of the incision being in healthy corneal tissue It must be remembered that if the operation is performed under cocaine the most excruciating pain is felt when the iris comes into contact with the cornea For this reason it is best to use a general anæsthetic, or infiltrate deeply with novocain

Saemisch's Section Instruments required speculum, fixation forceps, Graefe knife (Fig 133), smooth iris forceps, in case the iris should prolapse, the following should also be at hand two pairs of iris forceps, de Wecker's scissors iris repositor

FIG 133 Narrow Graefe knife

After anæsthesia, the eye is washed out and the speculum is inserted The eye is fixed with fixation forceps in the usual manner (vide p 210) The point of the Graefe knife is inserted in healthy cornea just outside the edge of the ulcer, preferably at the advancing part where the yellow crescent is densest The edge of the knife is directed forwards, so that if the lens advances before the section is complete it will touch the back of the knife and not be wounded The knife is passed across the anterior chamber until the point is seen beyond the opposite edge of the ulcer The counter puncture is made in healthy cornea here, and the knife is pushed on so as to cut out The aqueous pour

out, and carries with it much of the hypopyon. Atropine is instilled, and the eye bandaged.

If the ulcer is very large it is impossible to make the puncture and counter puncture in healthy cornea. In these cases, too, the knife usually cuts out as it is in the act of passing across the ulcer. If the hypopyon is very fibrinous it may be necessary to pull the coagulum out with the smooth iris forceps.

This procedure improves the conditions of nutrition of the cornea and evacuates the hypopyon. It is not to be advocated in mild or in the early stage of severe cases but as a last resource it may prove beneficial.

Instead of the ordinary sublimate lotion hydrogen peroxide may be used. Optochin or ethyl hydrocupreine, a quinine derivative is said to have a specific action on pneumococcic ulcers a 1 per cent watery solution of the hydrochloride is dropped into the eye frequently or it may be applied directly to the ulcer.

The diplobacillary hypopyon ulcer should be treated with zinc salts. Zinc sulphate solution (0 25—1 per cent) should be used every hour or two and an ichthyol (1 5 per cent) zinc sulphate (0 5 per cent) ointment applied to the lids.

In intractable cases zinc ionisation may be used, it is specially useful for diplobacillary cases but may be employed in others. The method generally employed is by means of a direct current of not more than 2 milli amperes. The amount of the dose is about 150 milli ampere seconds per zinc square millimetre to each square millimetre of ulcer. The zinc ions are liberated from the positive pole. The negative pole is applied to the cheek or nape of the neck. The positive electrode is a strip of zinc 1 mm square and about 8 mm long and is bent to approximate the size of the area affected to which it is gently applied. The eye is made anæsthetic with 4 per cent cocaine hydrochloride and thereafter 0 5 per cent zinc sulphate is instilled. A wisp of cotton wool is wrapped round the zinc to prevent injury to the tissue. For example to an area of 5 0 sq mm a current of 1 5 milli amperes may be applied for 20 seconds with a 5 0 sq mm zinc electrode. On completing the application the area treated has a greyish white appearance due to the deposition of zinc. This treatment may be repeated daily if necessary.

If the ulcer spreads treatment with the appropriate sulphonamide drug should be used (*v p* 693), and non specific protein therapy may be of value (*t p* 691).

The results of treatment of the severer forms of hypopyon

ulcer are disappearing This is largely due to the fact that they are seen too late In rabbits it is possible to control the development of pneumococcic ulcers by intravenous injection of an anti pneumococcic serum, if this be used sufficiently early This method has been adopted in man, but usually fails *The commonest cause of failure is the development of secondary glaucoma* The patients are usually elderly and therefore often have shallow anterior chambers In the absence of an ulcer one would hesitate to put atropine into such an eye from the dread of causing glaucoma (*vide* p 284) Now the presence of an ulcer, with the accompanying iritis and hypopyon, increases the risks of glaucoma from the use of atropine We are therefore on the horns of a dilemma, for atropine will have a beneficial effect in keeping the iris at rest and tending to diminish the iritis, and therewith the hypopyon The routine use of atropine is therefore justified, but the tension of the eye should be watched much more carefully than is usually done If the tension rises the effect on the cornea is extremely bad, for it diminishes the lymph flow and therewith the resistance of the tissues to bacterial toxins It is indeed a definite indication for prompt paracentesis or Saemisch's section ; otherwise the condition will go from bad to worse

If there is a mucocele the lacrymal sac should be excised as soon as possible (*vide* p 654)

Keratitis disciformis is probably a milder inflammation of the same type as hypopyon ulcer and is only rarely accompanied by a small hypopyon It is characterised by a central grey disc lying in the middle layers of the substantia propria The disc is sharply defined and often shows several concentric grey lines, rather like a target In the centre there is usually a denser "bull's eye" The slit lamp shows thickening of the cornea (Vogt), and often folds of Descemet's membrane This form of keratitis is not common It occurs generally in adults and is unilateral It is accompanied by moderate irritation, which, however, persists for several weeks or months, leaving a permanent opacity Owing to the central situation vision is considerably impaired There is no ulceration, but the inflammation is probably caused by ectogenous infection through a defect in the epithelium It is, however, regarded by some as an advanced stage of certain cases of superficial punctate keratitis (*q v*), and due to neuroparalytic changes in the fifth nerve (Verhoeff) Keratitis disciformis has been observed as a result of vaccinia affecting the lid margin, but is not always due to this cause It is little amenable to treatment

Mycotic Hypopyon Ulcer A rare form of hypopyon ulcer due to a fungus the aspergillus fumigatus, is occasionally met with In it the slough is dry in appearance, and is surrounded by a yellow line of demarcation which gradually deepens into a gutter As the name implies there is an hypopyon *Treatment* is the same as for other hypopyon ulcers

Ring Abscess See p 442

Phlyctenular Keratitis It has already been pointed out that phlyctens are commonly found seated upon the limbus They may also occur within the corneal margin The fact must be emphasised that the disease is essentially conjunctival, and when the cornea is affected it is the conjunctival element of the cornea viz , the epithelium and the superficial layers immediately underlying it, which suffers Phlyctenular keratitis does not necessarily result in ulceration so that in these cases it is incorrect to classify it as a purulent keratitis, but it is convenient to consider the corneal manifestations of the disease under this heading because the complications and their treatment are similar to those of corneal ulcers in general

Corneal phlyctens are localised infiltrations of exactly the same nature as conjunctival phlyctens They cause more pain and reflex blepharospasm (photophobia) than do the conjunctival ones, symptoms which are worse in the morning They may become absorbed without destruction of the overlying epithelium in this case they cause no permanent opacity The tendency for the epithelium to be destroyed or rubbed off is very great and the denuded surface easily becomes infected, usually by staphylococci (*vide* p 167) In this manner a small superficial ulcer is formed

Fig 134 — Fascicular ulcer travelling inwards towards the centre of the cornea (*After Nettleship*)

The corneal phlycten is a grey nodule slightly raised above the surface If the epithelium breaks down and an ulcer is formed the surface becomes covered with polymorphonuclear leucocytes and looks yellow The subsequent course depends probably upon the nature of the infection and the condition of nutrition of the patient It may deepen rapidly and even perforate, though this is comparatively uncommon

A very characteristic form of phlyctenular ulcer is the

fascicular ulcer (Figs 72 B 134) This is a serpiginous ulcer which steadily creeps over the cornea usually towards the centre advancing slowly for weeks It is supplied by a leash of vessels which lie in a shallow gutter and follow the advance of the ulcer The ulcer starts near the limbus and heals on the peripheral side, while the central margin remains grey and infiltrated As long as this infiltrated crescent is seen the ulcer is progressing It always remains superficial and never perforates When healing finally takes place the vessels gradually disappear but the whole of the track of the ulcer remains as a permanent opacity, densest however, where the ulcer stops

The severest cases of phlyctenular keratitis are accompanied by a diffuse deep lying infiltration The large greyish area is dotted over with minute spots The deep infiltration may disappear entirely, or it may become yellow and break down forming a large ulcer

Sometimes the phlyctens are so closely packed at the limbus that they become confluent and may even surround the cornea If they break down and form a *ring ulcer* an extremely dangerous condition is set up The nutrition of the whole cornea is endangered and even if total necrosis does not occur an extensive perforating ulcer may be formed at the margin

More commonly however a continuous infiltration of the limbus leads to the development of superficial vessels at the periphery of the cornea a condition which is called *phlyctenular pannus* (pannus eczematosus or scrophulosus) (Plate V Fig 2) Unlike trachomatous pannus (*q v*) it shows no special predilection for the upper part of the cornea It is thin and not very vascular and usually undergoes complete resolution though the course is generally very tedious It is accompanied by intense blepharospasm

Treatment of phlyctenular keratitis is the same as that of phlyctenular conjunctivitis (*q v*) until ulceration has occurred In these cases atropine is to be combined with the yellow oxide of mercury ointment If the latter causes much irritation or if the ulcer is at all deep simple atropine ointment should be substituted The yellow ointment is particularly beneficial in fascicular ulcers but may fail to stop their progress The crescentic infiltrate should then be cauterised with pure carbolic acid or the actual cautery, or the vessels may be destroyed with the actual cautery Pure *carbolic does not destroy* vessels efficiently, and whenever this is desired the actual cautery must be used These extreme measures are seldom required in phlyctenular keratitis If a fascicular ulcer has already

reached the centre of the cornea and lies over the pupillary area it is not a bad plan to allow it to progress still farther, because the opacity left by the track of vessels is less dense than that left at the final site of ulceration

Ring ulcer must be treated by hot bathings, atropine, and a pressure bandage   Some cases respond well to vitamin C (*vide* p 230)

Deep ulcers and the scars left by phlyctenular keratitis must be treated on general principles (*vide* p 204)

Phlyctenular ophthalmia is responsible for a vast amount of seriously impaired vision due to corneal opacities   The disease is a manifestation of general debility and is largely preventable   The worst effects would undoubtedly be avoided if the children could be transferred to better hygienic conditions in the country, and steps are now being taken to provide treat ment in convalescent homes for such cases

Marginal Ulcer   Apart from the ring ulcer of phlyctenular keratitis, ulcers not infrequently occur in this situation, especially in old, gouty people   They are shallow and little infiltrated, often multiple   They may be caused by the Morax Axenfeld diplobacillus   Sometimes they heal rapidly, but as rapidly recur, so that the process drags on indefinitely, to the detriment of the patient's health   Frequently the ulcers become vascularised and the vessels persist   More serious rare forms of deep marginal ulceration also occur in old people, resembling the phlyctenular ring ulcer sometimes leading to necrosis of the whole cornea   Chronic serpiginous ulcer (*vide* p 225) commences at the margin of the cornea Marginal ulcers are often accompanied by severe neuralgic pains in the face and head

Treatment   Diplobacillary ulcers should be treated with zinc salts (*vide* p 173)   The recurrent marginal ulcers of gouty people are best treated by painting the ulcer with weak silver nitrate solution, gr v to ʒ i   They often heal up quickly after this application combined with weak antiseptic lotions If it fails, touching the ulcer with pure carbolic or trichloracetic acid may be tried   Recurrence, however, can only be pre vented and that with difficulty, by constitutional treatment, which includes the special diets and drugs for gout, as well as fresh air and moderate exercise   The eyes should be protected with smoked glasses   If this treatment fails, and the ulcers are vascular, destruction of the vessels with the actual cautery is most likely to succeed   Sometimes eserine does good in these cases

In the deep ring ulcer of old people silver nitrate or the actual cautery may be used Paracentesis may be employed to avert perforation and improve the nutrition of the cornea Every attempt should be made to build up the constitution by a nutritious diet and tonics

Central Ulcer Symmetrical central ulcers of an extremely indolent type are not infrequently met with in a badly nourished children They probably occur here because this part of the cornea is farthest from the nourishing vessels They are quite superficial, show little infiltration and no vascularisation , they form shallow round pits or facets about 2 mm in diameter There is little or no reaction, either in the form of lacrymation or photophobia They do not spread either superficially or in depth, nor do they show any tendency to heal When they finally heal they often leave clear facets which only very gradually disappear They appear to have *nothing in common with phlyctenular keratitis except that* both conditions are indications of defective nutrition They are not uncommonly associated with trachoma

They sometimes occur outside the centre of the cornea, and may perforate allowing a knuckle of iris to prolapse This prolapse should not be cut off, owing to the relatively large gap in the cornea, and the defective powers of repair in the debilitated patient

Treatment must be directed especially to improving the general nutrition A few weeks in a convalescent home in the country will effect more than any local treatment Atropine and boric lotion are used locally Trachoma, if present, must be suitably treated

Keratomalacia is a rare disease in England affecting badly nourished children usually early in the first year of life The conjunctiva becomes dry and shows xerotic spots (*vide* p 192) T e cornea becomes dull and insensitive , the haze increases and yellow infiltrates form Finally the whole cornea necroses and may seem to melt away within a few hours A characteristic feature is the absence of inflammatory reaction In the rare cases in which the children are old enough to exhibit this symptom th disease commences with night blindness, they are able to see much better in the daytime than in the dusk The children are usually extremely ill and very frequently die Owing to their apathetic condition they do not close the lids, so that the cornea is continually exposed Both eyes usually become affected Streptococci have been found in the cornea and sometimes in the *blood* , *in other cases th*

pneumococcus is present Many of the children are syphilitic. Experiments on animals tend to show that the disease is due to the absence of fat soluble vitamin A in the diet

Treatment must be directed to the general health and environment Cod liver oil should be given or rubbed into the skin Halibut liver oil, 10 to 20 drops a day, or carotene in oil, 40 to 60 drops a day, are efficient substitutes for cod liver oil Subcutaneous injections of large quantities of normal saline solution are beneficial The lids should be kept closed under moist warm compresses The nutrition of the cornea is sometimes benefited by the use of eserine

Atheromatous Ulcers occur in old dense horneæ, especially such as have undergone degenerative changes resulting in the formation of hyaline fibrous tissue and calcareous deposits Such scars have little vitality, and the deposits act as foreign bodies They readily succumb to infection, the epithelium being badly nourished When ulceration once begins it proceeds rapidly and deeply, with little or no effort at repair Perforation takes place, and is often followed by panophthalmitis

Treatment The eye is frequently blind and disfiguring In such cases it is well to excise it at once, thus relieving the patient of much unnecessary misery If it is worth saving the condition must be treated on general principles

Keratitis e Lagophthalmo occurs in eyes insufficiently covered by the lids The epithelium of the exposed cornea becomes desiccated and the substantia propria hazy Owing to the drying the epithelium is cast off, and the cornea falls a prey to infective organisms

The condition is due to any cause which may produce lagophthalmia, e g , extreme proptosis as in exophthalmic goitre or orbital tumour, paralysis of the orbicularis, and so on The absence of reflex blinking is an important factor, as well s defective closure of the lids during sleep Patients extremely ill from any disease are liable to this form of keratitis

Treatment consists in keeping the cornea well covered In mild cases it is sufficient to bandage the eyes at night If possible the cause of the exposure must be removed In the meantime it may be necessary to keep the lids closed with plaster and a bandage, or partially to sew them together (*vide* p 227)

Chronic Serpiginous Ulcer (*Syn —Rodent Ulcer, Mooren's Ulcer*) This is a rare superficial marginal ulcer, usually occurring in elderly people, and spreading, if not checked, over the whole

cornea It commences by one or more grey infiltrates These break down, forming small ulcers, which spread and sooner or later coalesce The ulcer undermines the epithelium and super ficial lamellæ at the advancing border, forming a whitish over hanging edge, which is very characteristic The base becomes quickly vascularised It never perforates but goes on with intermissions for months, until eventually a thin nebula is formed over the whole cornea, and sight is much diminished There is sometimes iritis, and very rarely a small hypopyon In about a quarter of the cases both corneæ are affected, but not always simultaneously The cause is unknown

Treatment The overhanging edge should be cut off with scissors, and then the whole surface of the ulcer, and especially the margin should be well cauterised with the actual cautery, or with trichloracetic acid (10—20 per cent), and covered by a conjunctival flap A few cases have responded to repeated appli cations of absolute alcohol to the ulcers, to zinc ionization followed by covering with a conjunctival flap, or to β rays (*vide* p 187) More commonly treatment fails to stop the process, which has even been known to recur in the cicatrised cornea

Neuroparalytic Keratitis occurs in some cases in which the fifth nerve is paralysed It is relatively rare in nuclear and fascicular lesions within the central nervous system, unless the facial nerve is simultaneously involved Nor does it occur in all cases of peripheral lesion , thus, if the Gasserian ganglion is removed or the fifth nerve injected with alcohol for trigeminal neuralgia with proper precautions only a small proportion of the cases get neuroparalytic keratitis The disease has been known since the time of Majendie, and was attributed to special trophic impulses conducted by the nerve This theory was combated, and the view advanced that the condition depends upon the loss of sensation in the eye As a result, reflex blinking is more or less abolished, minute foreign bodies are not felt and therefore not removed, abrasions are unnoticed and unattended, so that ulceration is readily induced and pathogenic organisms have free play Neither of these theories satisfactorily accounts for the facts It will be seen that the disease of the cornea usually has a very characteristic nature, quite different from the ulceration of neglected injuries It is probable that the disease is due to irritative changes in or about the degenerating nerve, and that mere section or paralysis of the nerve is unable to produce the disease in the absence of such irritative conditions Some light has been thrown on the "trophic" function of sensory nerves by the work of Krogh, Dale, Lewis and others (*vide* p 17) They have

shown that antidromic impulse upon the cornea quite similar
large part in the automatic may be present, but are not always
tissues supplied by these neither the nose   The patients are usually
output of histamine like subs' condition, e g , influenza, pneu
skin and other lesions, such' , but it may be so trivial as to
the other hand, the important times occurs after typhoid inocu
shown by the fact that kerat rcely the size of a pin's head and
of both fifth nerves   When groups   They quickly rupture,
sensual reflex from the other eye and dly, leaving no opacity
the disease is more likely to occur if it appear, and the con-
paralysis of the orbicularis palpebrarum   cases ulcers are

    Besides these cases which result from radical treat due to
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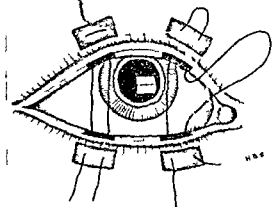
Fig 135.—Tarsorrhaphy

trigeminal neuralgia, neuroparalytic keratitis is caused by
intracranial tumours, gummatous basal meningitis, and
fractures of the skull   (*See* Chap XXIX)
    The characteristic feature of neuroparalytic keratitis is the
desquamation of the corneal epithelium   The surface of the
cornea becomes dull, and the epithelium is thrown off, first
at the centre, then over the whole surface except a narrow
raw at the periphery   The whole of the epithelium may peel
off intact   The substantia propria then becomes cloudy and
finally yellow, breaking down into a large ulcer, which is
usually accompanied by hypopyon   There is no pain, owing
to the anæsthesia, but ciliary injection is marked   A large
perforation occurs if the case is not speedily treated   In any
case the resulting leucoma is generally so large as to destroy

8—2

cornea   It commences by one or two ule the healed scar quickly break down, forming small ulcers ole process being repeated later coalesce   The ulcer undermin Gasserian ganglion sensation ficial lamellæ at the advancing bor hanging edge, which is very char ment of corneal ulcer should quickly vascularised   It never r ll care being devoted to the intermissions for months, until ev cidage   Improvement is often over the whole cornea, and sight r sometimes iritis, and very rar r r ce is relinquished the ulcera-quarter of the cases both r e t is best to suture the lids simultaneously   The them iture r for a long period only

Treatment r when the condit n of the weather—warmth, scissors r igh winds, and o on—are favo urable

tho anæsthetic is necessary since sen ation is lost in the conjunctiva and lids   The mucou membrane is dissected up om the margin of the lower li i ust posterior to the lashes ver rectangular areas abo 5 6 mm long on each side of the iddle of the lid   The edge of the upper lid is similarly reated at the corresponding positions   Two mattress sutures re then passed through rubber sheet and the skin so that they ome out at the posterior edge of the bare surface (Fig 13a), not on the posterior surface of the lid where they would rub against the cornea   After being similarly carried through the skin of the other lid and rubber they are tied, the freshened surfaces being brought into contact   In a few days, if the stitches have not torn out, the lids will be firmly adherent

The beneficial effect of suturing the lids on neuroparalytic keratitis is very striking   If, as often bandaging fails tarsorrhaphy will invariably succeed in stopping the process   Even if an hypopyon ulcer is present cicatrisation rapidly takes place and the hypopyon disappears   Recurrence of the keratitis however, very frequently happens if the lids are separated, even after many months

In the worst cases the eye is useless, and tends to become a source of perpetual trouble   It is then best to excise it which may be done without any anæsthetic if the ophthalmic branch of the trigeminal nerve is completely paralysed

Non suppurative Keratitis   This occurs in two types, superficial and deep   The superficial forms include some purely symptomatic conditions such as pannus   Some of them, such as herpes, may lead to the formation of ulcers and pass into the purulent type   The deep forms never suppurate

Herpes Corneæ   Herpes of the cornea occurs most commonly in herpes febrilis, more rarely in herpes ophthalmicus.

In *herpes febrilis* vesicles form upon the cornea quite similar in nature to those which may be present, but are not always so, upon the lips or angle of the nose. The patients are usually suffering from some febrile condition, *e g*, influenza, pneumonia, whooping cough, &c, but it may be so trivial as to escape observation. It sometimes occurs after typhoid inoculations. The vesicles are scarcely the size of a pin's head and are often arranged in rows or groups. They quickly rupture, forming abrasions which heal rapidly, leaving no opacity. Usually, however, fresh crops of vesicles appear, and the condition may prove very obstinate. In severe cases, ulcers are formed which may be of dendritic type, or may be due to secondary infection. The acute stage is accompanied by great irritation, lacrymation, and blepharospasm. The ocular affection is usually unilateral and on the same side of the face as vesicles on the lips, &c. The cornea is generally not anæsthetic except at the spots attacked.

Herpes corneæ may be mistaken for phlyctenular keratitis. The former occurs usually in adults, the latter in children. The clear vesicles differ in appearance from the grey infiltrations of phlyctenular keratitis. After the vesicles have burst, the shape and the total absence of vascularisation are distinguishing features. They are then liable to be mistaken for traumatic abrasions, from which they are distinguished by their grouping, the crenated edges when several have coalesced, persisting shreds of the ruptured vesicles, and the absence of history of any injury.

The commonest form of herpes corneæ is the *Dendritic Ulcer*. In it the vesicular stage is rarely seen, the epithelial wall of the vesicle being quickly broken. Minute shallow clear facets like abrasions, are found in the first stage. They may be easily overlooked. They generally cause much pain, lacrymation and blepharospasm.

Fig. 136.— Dendritic ulcer somewhat diagrammatic

They may spread in all directions, coalescing with others and forming a large shallow ulcer with crenated edges. More often grey striæ extend in one or more directions, increase in length and send out lateral branches, which are generally knobbed at the ends (Fig 136). In this manner a dendritic figure not unlike a liverwort, is formed. The surface over the infiltrates breaks down and an extremely irritating and

chronic type of ulcer is produced   Generally only one or two of the infiltrates stains with fluorescein at any given time, but fresh spots are continually being formed   It is often associated with frontal neuralgia   Such an ulcer may persist in spite of treatment for weeks or months, sending out fresh branches but never extending in depth   The disease not infrequently recurs

Dendritic ulcer is really a manifestation of herpes febrilis It sometimes occurs after prolonged treatment with arsenic, and also in subjects of malaria

Treatment   In herpes corneæ the eyes should be protected with a bandage   When the vesicles have ruptured, atropine and warm compresses give most relief   It is sometimes necessary to use pantocain when the pain is acute   Oily applications—of ricini, or parolein—are sometimes grateful. Prolonged ulceration must be treated according to the type of ulcer, whether dendritic or septic   The general health must be attended to, quinine, valerian salicyclic preparations, *e g*, salicylates, aspirin, &c, are useful

Dendritic ulcer may be carefully cauterised with iodine (7 per cent iodine and 5 per cent potassium iodide in alcoholic solution) on a swab, followed by instillation of pantocain, but pure carbolic acid is more efficacious   Absolute alcohol has been recommended for the purpose in these cases, but causes much pain after the pantocain has ceased to act   If caustics fail to stop the progress the actual cautery should be used Atropine &c and a pad and bandage are used, but in many cases it is advisable simply to use smoked glasses and get the patient out in the fresh air as much as possible   Sometimes for no known reason eserine is successful when atropine has failed to produce a good result   The general health must not be neglected, especially as the patient often becomes very depressed

Ultra violet light treatment has proved efficacious in some cases, the reaction is increased by previous instillation of 1 per cent fluorescein

Good results have been obtained by the administration of vitamin C (ascorbic acid)   It should be given intravenously on alternate days from " Roche " ampoules containing 500 milligrams   Generally 4 to 6 injections suffice, but should be followed by 2 tablets of 250 milligrams by the mouth three times a day

Superficial Punctate Keratitis is an uncommon condition allied to herpes febrilis, and, like it, usually associated with

influenza or catarrh of the respiratory tract ; but no vesicles are formed. It commences as an acute conjunctivitis At
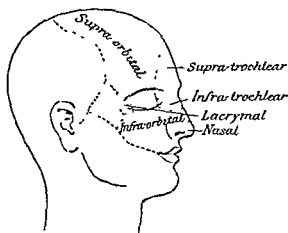
Fig 137.—Distribution of the branches of the ophthalmic division of the fifth nerve on the face

Fig 138 —Herpes ophthalmicus

this stage, or after it has passed off, groups or rows of super-ficial, slightly raised, grey dots are seen scattered over the

cornea least at the periphery They may or may not stain
faintly with fluorescein They may remain unchanged for
months, but gradually disappear some cases, however, pass
on to discoform keratitis $(q\,v)$ The disease affects one or
rarely both eyes usually in young people, and is accompanied
by irritation and lacrymation in the early stages, with some
defect of vision in the later Unlike recurrent erosion of the
cornea $(q\,t)$, which may occur in similar circumstances without
known trauma, it does not recur An acute superficial
punctate keratitis occurs in epidemic form in India

Treatment as for herpes In *herpes ophthalmicus* one or
more of the branches of the ophthalmic division of the
fifth nerve (Fig 137) is marked out by rows of vesicles
or the scars left by them, exactly as in herpes zoster in
other parts of the body The supra-orbital, supra and
infra trochlear branches are nearly always involved,
frequently the nasal branch only rarely the infra-orbital
branch It is very rarely bilateral There may be fever and
malaise at the onset and the eruption is preceded by severe
neuralgic pains along the course of the nerves These are so
characteristic that they should arouse suspicion of the nature
of the disease before the vesicles appear The pain sometimes
ceases after the outbreak of the eruption, but not always, and
it may continue for weeks or months The skin of the lids
and other areas affected becomes very red and œdematous so
that the disease is often mistaken for erysipelas The charac-
teristic distribution and especially the strict limitation to one
side of the middle line of the head should obviate this error
The vesicles often suppurate, bleed and cause small permanent
pitted scars The active eruptive stage lasts about three weeks
and is followed by some anæsthesia of the skin Ocular
complications arise during the subsidence of the eruption, but
may be overlooked during the acute stage owing to the difficulty
in examining the eye

With the slit-lamp rounded spots, composed of minute white
dots, which fuse into irregular areas, are seen Vesicles are
rare, but when they occur are exactly like those of the febrile
form, and behave in the same manner More commonly
there is a diffuse deep infiltration of the cornea (*keratitis
profunda*), associated with iridocyclitis $(q\,t)$ The cornea
is usually insensitive This is tested by touching it with
a wisp of cotton wool, and comparing with the opposite
eye The slightest touch is followed by reflex closure of the
lids if the cornea is sensitive The intraocular tension is not

infrequently somewhat diminished in the early stage The eye lesions are very obdurate and often persist long after the disease has otherwise passed away In some cases there is associated paralysis of motor cranial nerves especially the third, sixth and seventh It usually passes off within six weeks Facial palsy adds seriously to the risk of the eye, owing to its partial exposure

Apart from permanent scarring of the cornea and the evil effects of iridocyclitis, anæsthesia of the cornea may persist for months Nodules of scleritis may occur about two months after the disappearance of the rash (Doggart), and patches of atrophy in the iris are common Quite acute pain, with impairment of sensitivity, may persist in the affected skin for months or even years

Herpes ophthalmicus occurs at any age, but generally in elderly people. Not infrequently there is a history of contact with patients suffering from chicken pox, and evidence is accumulating that the relationship is more than a mere coincidence It may account for the fact that herpes zoster is apt to occur in epidemics, which are more common in the spring and autumn than at other times

The disease is due to lesions in the Gasserian ganglion of the same type as those found in the posterior root ganglia in herpes zoster, i e, microscopic thromboses and hæmorrhages similar to those found in the anterior cornual nuclei in anterior polio myelitis This disease shows many analogies on the motor side to herpes zoster and there is some evidence that posterior poliomyelitis is associated with the posterior root lesions of herpes (Lhermitte) Probably both are caused by infection, the lesions being due to a virus Herpes ophthalmicus has been known to follow involvement of the Gasserian ganglion in a malignant growth, gummatous meningitis or arsenic poisoning e g, with salvarsan The cases associated with motor palsies usually the 3rd nerve, and rare cases with optic atrophy, are also probably cases of symptomatic herpes and not due to the herpes zoster virus In all cases the skin lesion is probably due to antidromic impulses liberating histamine like bodies, and the spread of the vaso-dilatation may well be due to axon reflexes

Treatment The eye should be carefully examined in every case of herpes ophthalmicus, the lids being separated by retractors if necessary Oily drops or paroleïn and atropine should be instilled Keratitis and iridocyclitis must be treated in the usual manner The skin may be treated with cocaine ointment (1 per cent) and dusted with starch powder Quinine

is generally given internally and aspirin to relieve the
If the pain is severe it may be relieved by intramu
injection of pituitrin   The patient should be kept in
during the acute stage

In acne rosacea, generally in elderly women, keratitis asso
with much irritability and lacrymation may occur   In ad
to slight muco-purulent conjunctivitis (*vide* p 149), greyish
infiltrates and small ulcers appear in the cornea   They are
intractable and frequently recur   In severe cases there is also
The local treatment should be similar to that for phlyctə
keratitis, and calomel insufflation gives good results,
application (one third of an erythema dose) of X rays has
found beneficial (Greeves) , the essential treatment, howev
that of the skin condition, which, combined with suitable
alone ensures freedom from relapses

Interstitial Keratitis (*Syn —Parenchymatous Keratitis*)
deep keratitis usually affecting children between the ag
five and fifteen, the subjects of congenital syphilis
commoner in girls than boys

After slight irritative symptoms, with some ciliary
gestion, one or more hazy patches appear in the cornea,
the margin or towards the centre (Plate VII , Fig 1)   If
are near the margin they push forwards towards the cen
if at the centre, others appear and fuse, until finally the w
cornea looks lustreless and dull   Minute examination sl
that the patches are in the deep layers and are made u
denser spots and fine streaks   In two to four weeks the w
cornea is hazy with a steamy surface, giving a general app
ance like that of ground glass   Denser spots can alway
seen in the general mist   In the severest cases the w
cornea becomes quite opaque, so that the iris is hidden ,
rule the iris can be seen dimly

Meanwhile vascularisation has occurred   It is of deep t
(*vide* Fig 71, p 91), consisting of radial bundles of brush
vessels   The larger marginal plaques may be very vascul
as they are covered by a layer of hazy cornea, their br
scarlet is toned down to a dull reddish pink ("saln
patches ")   *The separate vessels can only be seen by mag*
fication   The small salmon patches are often crescent
when larger they are sector shaped   The opacity extend
little beyond the vessels, which seem to push the opacity
front of them   In the acme of the condition the vessels run
radial bundles almost, but seldom quite, to the centre of
cornea   Vascularisation is probably brought about for

supply of protective substances which cannot reach the cornea by the normal process of diffusion   There is often a moderate degree of superficial vascularisation, greater in some cases than in others, but never extending far over the cornea   The conjunctiva may be heaped up like an epaulette at the limbus, so that some slight resemblance to phlyctenular keratitis may be seen   Indeed it is probable that these patients are both syphilitic and tuberculous

After the disease has reached its height it commences to subside   The cornea clears from the margin towards the centre, which may long remain hazy, though it too finally clears except in the worst cases   As the cloudiness disappears the vessels become obliterated, but though they cease to carry blood they remain permanently as fine opaque lines , they can be demonstrated only by magnification either with oblique illumination or more definitely by the direct method (*vide* p 122), or with the slit lamp   The cornea should be examined in the dark room by oblique illumination with a corneal loupe, when the vessels will be seen as grey lines on a black background   It should then be examined by the direct method with a + 20 D lens behind the mirror   The edge of the pupil is brought into focus, and then either the head is withdrawn slightly or plus lenses are added, the head being kept still, until the cornea is in focus   The vessels will then be seen as black lines against a red background   The characteristic radial course and distribution (*vide* Fig 73, p 91) affords permanent proof of previous occurrence of interstitial keratitis, and is important evidence of congenital syphilis

At the height of the disease vision may be reduced to finger counting or hand movements   and there is much lacrymation and reflex blepharospasm   Very mild cases are met with in which the patches of cloudiness are thin, scarcely vascularised at all, and clear up quickly   In the marginal type the opacity may be limited to a sector

The surface very rarely becomes ulcerated   It is frequently stippled, steamy and slightly uneven, and this condition may persist   In the worst cases the cornea may be enormously thickened and gelatinous in appearance   The impression given is that the cornea is very ectatic and that the eye is in a hopeless condition   it will probably clear up well with useful vision   In no case must an eye be removed on account of interstitial keratitis

Interstitial keratitis is almost invariably symmetrical though an interval of three or more weeks usually intervenes

before the onset in the second eye. Rarely the interval is several months or even years. The acute stage lasts at least six weeks and may extend to several months. The clearing of the cornea takes many weeks or months, but not much improvement can be expected after eighteen months. Delayed interstitial keratitis, *i.e.*, in patients over thirty, occasionally occurs, and is more liable to be unilateral; it is often very severe. Interstitial keratitis in acquired syphilis is uncommon, though probably not so rare as is generally thought; it is also generally unilateral: several cases have been reported in which the primary lesion has been on the lids or face, and the keratitis has been limited to the same side. Most of the
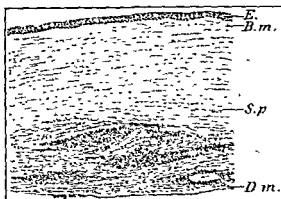
Fig. 139.—Section of interstitial keratitis, showing infiltration confined to the deeper layers of the substantia propria (× 60). *E*, epithelium; *B.m.*, Bowman's membrane; *S.p.*, substantia propria; *D.m.*, Descemet's membrane with endothelium.

reported cases have occurred about two years after the primary sore, but the interval may be much shorter or longer.

There is evidence of relatively high mortality among the children of mothers who have had interstitial keratitis.

In some cases interstitial keratitis follows an injury to the eye, such as a blow or operation, *e.g.*, tenotomy. I have seen it follow an attack of phlyctenular conjunctivitis. Apparently the injury acts as an exciting cause in a subject naturally prone to the disease, usually a congenital syphilitic.

Pathology. Microscopy during life with the slit-lamp shows haziness ("bedewing") of the epithelium, probably due to œdema, cloudy opacities in the deep layers of the substantia

propria, and thickening of the cornea Folds of Descemet's membrane and precipitates on the posterior surface sometimes appear at a very early stage Later, deep vessels of characteristic distribution are seen Resolution is accompanied by definite thinning of the cornea

The rare cases of interstitial keratitis which have been examined anatomically show that the infiltration of the cornea is almost entirely limited to the deeper layers lying immediately anterior to Descemet's membrane (Fig 139)

It has been pointed out that corneal conditions which are secondary to conjunctivitis are superficial Similarly deep keratitis is secondary to disease of the uveal tract Thus, in tubercle of the iris (*q v*) it is not uncommon in the late stages to meet with an interstitial keratitis fundamentally the same as in congenital syphilis Further, anatomical investigation has shown that in the latter form the uveal tract is profoundly affected Thus, it is the rule for a considerable degree of iritis to be present Sometimes there is severe cyclitis, as shown by the presence of precipitates ("keratitis punctata," *vide* p 271) on the back of the cornea Not infrequently there is choroiditis If the pupil of the unaffected eye is dilated and the periphery of the fundus carefully examined, patches of anterior choroiditis will not uncommonly be found All these facts support the view that the disease is fundamentally a uveitis, and that the keratitis is secondary, *i e*, merely symptomatic Clinically it masks the uveitis, which is thus liable to be overlooked, and hence the disease is called a keratitis It is very important to realise the true pathology, since treatment must be directed to avoiding the deleterious results of iridocyclitis rather than those of keratitis

The earliest manifestation of iridocyclitis can be demonstrated in the second eye at the onset of inflammation in it If fluorescein is repeatedly instilled it becomes absorbed like atropine, &c Careful examination will then show a greenish marbling at the back of the cornea, due to changes in the endothelium lining Descemet's membrane This does not occur in the normal eye

It is probable that anaphylaxis plays some part in the pathogenesis of interstitial keratitis (Wessely, von Szili), and may account for the occurrence, after a latent period, of the disease in the second eye

Ætiology It has already been stated that nearly all cases which are not obviously secondary to tubercle of the iris, &c —and these are rare—are due to congenital syphilis Many

surgeons, however, consider that interstitial keratitis is not infrequently due to tubercle Owing to the importance of diagnosing congenital syphilis in doubtful cases the principal signs of this complaint may be enumerated

(1) General features Prominence of frontal eminences, flatness of the bridge of the nose, breadth of face, stupidity or undue precocity, deafness

(2) Hutchinson's teeth (Figs 140–145) There is nothing characteristic in the first dentition In the permanent teeth only two, the upper central incisors, are to be relied upon,

Fig 140

Fig 141

Fig 142

Fig 143

Fig 144

Fig 145

Figs. 140 to 145 —*Hutchinson's teeth*

but the other incisors and first molars are often deformed The characteristic change in the central upper incisors appears to depend upon defective formation of the central lobe (Figs 141, 144, 145) Soon after eruption this lobe wears away, leaving a vertical notch at the centre of the cutting edge (Fig 140) If the cause has acted so intensely as to prevent the development of the central lobe, there is, instead of a notch, a narrowing and thinning of the cutting edge as compared with the crown, and this according to its degree produces a resemblance to a screwdriver or peg (Figs 142, 143) The teeth are too small in every dimension, so that the incisors are separated from one another by considerable spaces In extreme cases all the incisors are peggy and much dwarfed

The changes are usually symmetrical, but Fig 144 shows one tooth typically deformed and the other normal

(3) Linear cicatrices, relics of former rhagades, are met with at the angles of the mouth Cicatrices on the hard or soft palate or elsewhere in the mouth point to antecedent syphilitic ulcerations

(4) Shotty, painless, lymphatic glands are felt in the neck, especially in the posterior triangle

(5) Hard periosteal nodules, best found upon the shins, and chronic synovitis of the joints, especially the knee joints, may be present

Evidence of acquired syphilis may be sought in the parents, *e g*, history of miscarriages, &c In cases of doubt, the Wassermann test should be applied

As already mentioned, interstitial keratitis also occurs in acquired syphilis, and it has been attributed to malaria, myxœdema, trypanosomiasis, &c It frequently occurs in foxhounds and other highly bred dogs, and I have seen it in dogs after the thyroid gland has been removed

Treatment It is usual to order antisyphilitic remedies, but, as in parasyphilitic diseases of the central nervous system, it is doubtful if they have any influence over the course of the disease, partly because the cornea is non vascular Mercury inunctions, or powders or pills of mercury combined with chalk and ipecacuanha or perchloride of mercury may be given Iodide is best administered to children in the form of syrup of iodide of iron, and may be combined with syrup of phosphates as a tonic Salvarsan and its substitutes have proved disappointing The administration of thyroid gland has proved serviceable in some cases Cod liver oil or maltine may be used when there is a tuberculous element about the condition, and in all cases general hygienic régime must be instituted

Local treatment consists in guarding against the evil effect of the uveitis which is an invariable accompaniment of the disease Atropine is ordered as a routine measure, with the double purpose of keeping the ciliary body and iris at rest and preventing the formation of posterior synechiæ There is often great difficulty in getting the pupil to dilate, probably owing to defective penetration of the drug through the diseased and vascularised cornea Hot bathings or radiant heat should be used frequently in the acute stage In obstinate cases with much lacrymation and blepharospasm, especially if the pupils will not dilate with atropine, leeches applied to the temple do good (*vide* p 268), or mydriacin (*vide* p 692) may be tried Smoked glasses are ordered

In some cases pain and blepharospasm are so severe that no relief is obtained by the usual measures   The retro-ocular injection of 1 5 c.c. of novocain (4 per cent) into the region of the ciliary ganglion, followed seven minutes later by 1 c c of alcohol (40 per cent) is effective   A fine needle, 5 cm long is passed along the junction of the lower and outer walls of the orbit for 4 cm and is then turned medially and upwards for 1 cm   The plunger of the syringe is withdrawn slightly to ensure that it has not entered an orbital vein   The injections are made slowly, and a firm pad and bandage applied   The pain and blepharospasm are relieved, vascular congestion much reduced and the child is able to tolerate light   In some cases symptoms recur after two weeks, and a testimony as to
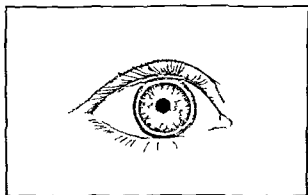
FIG 146 —Arcus senilis

the efficacy of the treatment is that the child may ask for another injection   No ill effects have hitherto occurred

In later stages the means used for clearing corneal cicatrices (vide p 206) depending essentially upon improving the lymph flow through the cornea, are also indicated for the opacities of interstitial keratitis   Prolonged use of yellow oxide of mercury ointment, combined with atropine in the earlier stages, is commonly made   it should be well massaged into the eye

Other forms of deep keratitis, e g , the central deep keratitis of adults, senile marginal deep keratitis, sclerosing keratitis (vide p 252) occur.

Keratitis profunda is the name given to a central deep infiltration of the cornea of indefinite origin   Such a condition occurs after contusion of the eye, and in this case usually clears up rapidly   In other cases a deep grey opacity, seen on magnifica

tion with the loupe to be composed of dots and striæ, occurs in the centre of the cornea in adults There is little irritation, and very little if any, vascularisation It begins to clear up after four to eight weeks but may leave permanent diffuse opacities It has been attributed to cold, malaria, and other causes It should be treated with the same local remedies as for interstitial keratitis

Keratitis marginalis profunda occurs rarely in old people, commencing as a greyish yellow infiltration, one or two millimetres broad, continuous with the sclera It is usually limited to the upper part of the cornea, but occasionally forms a complete ring The slight irritation subsides in a week or two, leaving a permanent opacity, resembling arcus senilis, but unlike it, continuous with the sclerotic

DEGENERATIVE CHANGES IN THE CORNEA

Arcus senilis is a fatty degeneration of the cornea met with in old people (Fig 146) It commences as a crescentic grey line concentric with the upper and lower margin of the cornea The extremities of the crescents *finally meet,* and an opaque line, thicker above and below, is formed completely round the cornea It is characterised *by being separated from the* margin by a narrow line of comparatively clear cornea It is sharply defined on the peripheral side, fading off on the central It is never more than about 1 mm broad, and is of no importance, either from the point of view of vision or of the vitality of the cornea

Arcus juvenilis is exactly similar to arcus senilis, but is a rare condition found in children Even arcus senilis may develop at a comparatively early age, but the juvenile condition is probably congenital It is of no importance The characteristic diagnostic feature of both these opacities is the presence of a line of clear cornea between them and the limbus This is occasionally found in old sclerosing keratitis, but in this case the opacity is usually localised to some one part of the cornea and extends farther towards the centre

Band-shaped Opacity (*Syn. —Transverse Calcareous Film, Zonular Opacity*) This is a common condition in old, blind, shrunken eyes It is due to defective nutrition and exposure It lies entirely in the interpalpebral area, commencing at the inner and

Fig 147—Band shaped opacity of the cornea from an eye with iridocyclitis

outer sides, and progressing until it forms a continuous band across the cornea (Fig 147)　Near the corneal loops, just inside the limbus, the cornea is generally relatively clear, as in so many degenerative conditions—probably owing to the better nutrition close to the blood vessels　The condition is due to hyaline degeneration of the superficial parts of the substantia propria, followed by the deposition of calcareous salts

As a rare condition it is found in otherwise healthy eyes, sometimes as a horizontally oval area in the palpebral fissure, usually in both eyes

Treatment　In the rare form last mentioned, improvement of vision may be obtained by scraping off the opacity, which is usually calcareous and quite superficial.　In the common form the eye is blind, and nothing remains but to remove it if it is painful or unsightly

Other Degenerative Changes are frequently met with in old leucomata, anterior staphylomata, and so on　They consist of hyaline degeneration calcification, &c　Such scars are liable to a serious form of ulceration (*vide* p 225)

Rare degenerative conditions are *nodular* and *reticular* (grill or lattice-like) *opacities*　They occur as a familial disease, usually picking out the young males of a family and commencing at about the age of ten or twelve　Opaque dots or forked lines appear under the epithelium in the centre of the cornea and slowly increase in number, but never invade the ring of cornea close to the margin.　There is little inflammatory reaction and the cause

Fig 148 —Senile marginal atrophy (Knhy)

is unknown　Vision is gradually obscured and treatment is of little avail　I have seen grey mosslike opacities, apparently of similar nature, with the same distribution in the corneæ of elderly people. Examination with the slit lamp shows that some of these cases have thickened corneal nerves and nodular swellings of the nerve-endings　Others show folds or ruptures of Bowman's membrane

Senile marginal atrophy, in which a gutter forms in the periphery of the cornea in the situation of an arcus senilis, occurs rarely in one or both eyes of old people　The gutter may become ectatic (Fig 148)

ECTATIC CONDITIONS

It has already been stated that ectatic conditions of the cornea may result from inflammation, viz , keratectasia (*vide*

p 201), and anterior staphyloma (*vide* p 203)   Two forms of ectasia of non inflammatory origin are known, viz, keratoconus and keratoglobus

Anterior Staphyloma is a protuberant cicatrix arising *from a prolapse of the iris, it may be partial or total* (p 203)   It may follow a perforating wound, but is usually due to perforation of an ulcer, especially such as is caused by ophthalmia neonatorum   The primary protrusion occurs at the moment of prolapse   Cicatrisation follows, and in the case of small prolapse may lead to flattening of the scar   In other cases of small, and in all cases of large, prolapse the con traction of the scar tissue is insufficient to bring this about, and the soft cicatrix yields to the normal intraocular pressure   Generally the prolapse of the iris leads to blocking of the angle of the anterior chamber, the intraocular tension rises, and the cicatrix yields still more, or if it was previously flat, secondary protrusion takes place

Partial staphylomata are usually conical   rarely hemi spherical, they usually extend to the margin on one side   Total staphylomata are usually hemispherical, rarely conical   There is invariably a rim of cornea around the pseudo cornea, this rim being well nourished by the peripheral blood vessels and never necrosing through ulceration   The thickness of the staphyloma varies very greatly in different cases, and often in different parts of the same staphyloma   In the latter case *bands of cicatricial tissue develop, while the intermediate parts* project , in this manner a racemose staphyloma is produced   Owing to the rise of intraocular tension the whole eyeball expands, especially in children, in whom the walls are relatively plastic   If the lens has not been expelled when the ulcer perforated, as sometimes happens, it is flattened, the expansion of the ciliary ring causing stretching of the suspensory liga ment   Owing to contact of the lens with the inflamed cornea after perforation the anterior capsular cells of the lens often proliferate and form an anterior capsular cataract (*q v*)   The high intraocular pressure also causes cupping of the optic disc

The pseudo-cornea is formed by organisation of the exudates on the surface of the prolapsed iris   It consists of fibrous tissue covered by epithelium, and lined by rarefied iris pigment epithelium   The epithelium on the anterior surface is often very thick and epidermoid , the fibrous tissue often undergoes degeneration   The anterior chamber is obliterated in total staphyloma, while the posterior chamber is enormously enlarged, and filled with yellow albuminous fluid

The sight is always diminished, and in total staphyloma is reduced to perception of light or total blindness   The eye may project between the lids so that a xerotic condition is set up and atheromatous ulcers may form   Ectropion of the lids may occur mechanically   The tension is raised, either as the cause of the protrusion, or as a result of the blockage of the angle of the anterior chamber (Chap XIV)   This may lead to pain   The staphyloma may be so thin that rupture occurs on the least injury, and may be several times repeated

Treatment   Total anterior staphyloma is best treated by excision of the eye, with or without the insertion of a glass globe in Tenon's capsule   Patients will often prefer to keep the eye if it is painless and not too disfiguring

Various methods of ablation in which the anterior part of the eye is removed and the contents scooped out, have been devised as an alternative to excision   They give a movable stump on which to set an artificial eye, but there is an objection that they are not entirely free from the danger of causing sympathetic ophthalmia (q v)

Treatment of partial staphyloma is directed to obtaining flattening of the cicatrix, preventing or relieving increased intraocular tension and improving sight   The attempts which should be made at the early stage have already been described (*vide* p 214)   Iridectomy is sometimes advisable with a view to improving vision and preventing or curing glaucoma (q v)   It cannot be performed at the site of the staphyloma since there is no anterior chamber here, but must be done at the clearest part of the cornea

Keratectasia differs from anterior staphyloma in that the iris takes no part in it   Its causation and prevention have already been discussed (*vide* p 201)   Sometimes the whole cornea expands producing a condition which is almost identical with the keratoglobus (*vide* p 246) of infantile glaucoma, though due to a different cause   When it is fully developed treatment is useless

Keratoconus (*Syn —Conical Cornea*) is probably due to a congenital weakness of the cornea, though often it only manifests itself after puberty   The cornea is thin and weak near the centre, and gradually bulges forwards more and more , the apex is always slightly below the centre   Sometimes it pulsates synchronously with the arterial pulse, and this may cause a subjective apparent pulsation of the objects looked at   The pulsation may be demonstrated with Schiotz' tonometer   The cornea is at first perfectly transparent, and vision is

impaired through the protrusion and alteration in curvature
If advanced the conical shape is easily recognised in profile
In the less advanced cases distortion and diminution in the
size of the corneal reflex over the centre is the chief guide
These changes are best seen when the reflex from a large flat
disc painted with broad concentric black and white lines
(Placido's disc or keratoscope) is observed through a hole in
the centre of the disc, or when the cornea is examined with the
ophthalmometer   With the ophthalmoscope mirror at a dis-
tance of 1 metre a ring of shadow concentric with the margin is
seen on the red reflex, altering its position on moving the mirror.
It is due to a zone through which few rays pass into the
observer's eye owing to the emergent rays on the central side
being convergent whilst those on the peripheral side are
divergent

The patient becomes myopic, but the error of refraction
cannot be satisfactorily corrected with ordinary glasses owing
to the hyperbolic nature of the curvature   The condition is
almost invariably bilateral, though frequently more advanced
on one side than the other   It may be slight and very slowly
progressive, or the reverse   In the later stages the apex
shows fine more or less parallel striæ, anastomosing at acute
angles, best seen with the slit lamp, and also discrete
opacities which become confluent   A brownish ring probably
due to hæmosiderin, may form in the epithelium encircling the
cone (Fleischer's ring)   Sometimes there are ruptures in
Descemet's membrane   Ulceration, rupture of the cornea,
increase of tension, and so on, do not occur

Treatment   In the early stages every effort should be made
to improve vision with glasses and the progress should be
carefully watched   In rare cases in which they could be borne
contact glasses (*vide* p 535) have been very beneficial   Various
methods have been adopted to stop the process   Miotics are
probably useless   The best treatment is cauterisation of the
apex with the actual cautery   The cauterisation at the extreme
apex must be deep, and perforation here has been advocated
The latter procedure is not without danger to the eye from the
formation of a corneal fistula, anterior synechia, infection, &c
Some operators remove a small wedge shaped slice from the
thickness of the cornea at the apex   This is more difficult to
perform and does not give better results on the whole than the
cautery   The scarring from cauterisation is much less than
might be anticipated, but it may be advisable to do an optical
iridectomy if vision is still very bad   Anterior sclerectomy

(trephining) has been performed for conical cornea, but without advantage

Keratoglobus (*Syn —Megalocornea*) is a hemispherical protrusion of the whole cornea occurring bilaterally in males it is familial and hereditary It differs from buphthalma (q 1) in that the intraocular pressure is normal the cornea clear, the angle of the anterior chamber normal and there is no cupping of the disc It appears to be a congenital overgrowth and is not infrequently associated with arachnodactyly

SYMPTOMATIC CONDITIONS

There are many pathological conditions of the cornea which are merely evidence of disease in other parts of the eye or
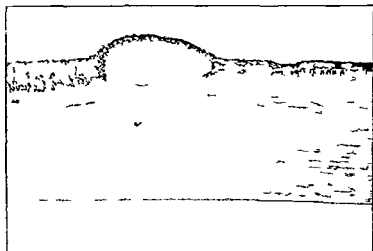
FIG 149 —Œdema of the cornea and vesicular keratitis from a glaucomatous eye (× 60)

of extension of disease Some are often described as true diseases of the cornea notably as forms of "keratitis" This involves a wrong principle and a misuse of terms which can only lead to confusion Since it is of great importance to distinguish these conditions from primary affections of the cornea both from the points of view of diagnosis and treatment it will be well to review the more common here

In glaucoma there is nearly always uniform diffuse bluish haze of the whole cornea It is due to alterations in the refractive conditions of the corneal elements brought about by the

increased intraocular pressure, and not to any gross patholo-
gical change. If the condition persists the cornea becomes
hazy throughout, and this haziness, unlike the former, does
not immediately disappear when the intraocular tension is
relieved. Here there is definite œdema, due to the impedi-
ment which prolonged tension causes to the diffusion of
lymph. It manifests itself first in the epithelium, which
becomes steamy and stippled. Sections show that this is due
to accumulation of fluid in and between the cells, especially the
basal cells (Fig. 149). Fluid also accumulates between the
lamellæ and around the nerve fibres. If the œdema lasts for
a very long period, as in eyes blinded with absolute glaucoma,
the epithelium may be raised into vesicles or bullæ (*vesicular
or bullous* "*keratitis*"). The evidence of prolonged tension
makes it easy as a rule to distinguish this condition from
herpetic vesicular keratitis; moreover the vesicles or bullæ
have firmer epithelial walls and show less tendency to burst.

Nearly allied to bullous "keratitis" is the formation of
epithelial threads, which adhere to the cornea by one end,
while the other, which is often club-shaped, hangs down free.
This is commonly called *filamentary* "*keratitis.*" It occurs in
the same conditions, i.e., usually associated with glaucoma,
but it may be seen rarely without any apparent cause in cases
of the herpetic type.

Keratic precipitates, usually badly termed "keratitis punc-
tata" or "k p" in England, are often deposited upon the
back of the cornea in cyclitis and iridocyclitis. The greatest
care must be taken not to overlook them, since they may
be almost the only objective sign of serious disease. They
may be on the back of a clear cornea or the deeper layers
may be infiltrated as a result of the iridocyclitis; thus, they
are not uncommon in interstitial keratitis. Their appearance
and nature will be described in discussing their cause
(*vide* p 271).

Opacities of the cornea are often secondary or symptomatic.
Such are the grey or white, usually tongue-shaped marginal
opacities which follow scleritis. Owing to their resemblance
to the sclerotic they are called *sclerosing* "*keratitis*" (*vide*
p 252).

Congenital opacities of various kinds are sometimes met with.
Many are not truly congenital but are due to injury received
at birth. Birth injury of the cornea takes the form of temporary
diffuse opacity due to œdema, or of permanent vertical grey
linear opacities due to ruptures of Descemet's membrane.

Striate opacity occurs in various forms   The commonest form is that seen after operations upon the globe in which a peripheral corneal section has been made as in cataract extraction   Here when the section is above delicate grey lines run down vertically from the wound and may pass completely across the cornea (Fig 150)   They can be seen clearly only by magnification   They disappear spontaneously as the wound heals   They are due to slight folding of the cornea whereby Descemet's membrane and the adjacent lamellæ become wrinkled   Radial striæ are seen around wounds or ulcers   they are partly referable to the same cause partly to distension of the interlamellar spaces by œdema   The fine hatching which is seen around ulcers and sometimes after tight bandaging is to be referred to similar causes

Fig 150 — Striate opacity of the cornea above for extraction of cataract

Opacities of the cornea may be due to improper treatment   One of the commonest is due to *deposits of lead salts* upon an abrasion or ulcer   An insoluble densely opaque white film is precipitated and adheres very firmly   The spot is sharply defined and looks like white paint   Probably the deposit is always thrown off eventually   but a very long time may elapse   An attempt should be made to scrape it off   but it is wisest never to use lead lotions at all in the treatment of any affections of the eye   They can always be replaced by equally efficient substitutes

White Ring Opacities (Coats)   Occasionally a ring or oval about 0 5 mm in diameter composed of very dense white spots occur on Bowman's membrane   The cause is unknown   they do not interfere with vision

Pigmentation of the cornea may also occur from improper treatment   Prolonged use of silver nitrate as a paint or in the form of drops is followed by dark brown staining of the conjunctiva and slight staining of the cornea   The condition is called *argyrosis* (*vide* p 193) and in the conjunctiva is found to be due to impregnation of the elastic fibres with metallic silver   in the cornea Descemet's membrane is stained   It is permanent   hence silver solutions including protargol argyrol &c, should never be ordered as drops or for use at home, at any rate without stringent injunctions

Blood in the cornea is rare   It may occur as a bright red spot quite superficially at the margin or as a greenish or rusty stain over the whole surface   In the latter case it is derived from blood in the anterior chamber, associated with high tension—a relatively infrequent combination (*vide* p 433)

Tumours of the cornea so called, are probably always secondary extensions, most commonly from the conjunctiva, the limbus being a favourite situation for these growths (*vide* p 194)

CHAPTER XII

Diseases of the Sclerotic

REDNESS of the white of the eye is caused by a variety of conditions   The commonest is conjunctivitis, the next common some inflammation of the anterior part of the uveal tract, viz, the iris and ciliary body   Some of the distinctive characteristics of the redness in conjunctival and ciliary inflammation have already been pointed out (*vide* p 83)   Redness of the white of the eye may also be caused by inflammation of the sclerotic, and it is a frequent error among beginners to ascribe the other forms to this disease   It must therefore be borne in mind that episcleritis and scleritis are relatively uncommon

INFLAMMATION OF THE SCLEROTIC

Two forms of inflammation of the sclerotic are described, superficial or episcleritis, and deep or scleritis   They might equally well be considered mild and severe forms of the same disease, *but the distinction is convenient clinically since they* usually differ in the course they take

Episcleritis is an inflammatory affection of the deep sub-conjunctival connective tissues, including the superficial scleral lamellæ   A circumscribed nodule, which may be as large as a lentil, appears usually two or three millimetres from the limbus (Plate VII, Fig 2)   It is hard, immovable, and very tender, the conjunctiva moving freely over it   It is traversed by the deeper episcleral vessels, and therefore looks purple, not bright red   It is extremely chronic, never ulcerates, and may be entirely absorbed, but more frequently leaves a slate-coloured scar behind, to which the conjunctiva is adherent   The cornea and uveal tract rarely participate in the inflammation

There may be little or no pain, but usually there is a feeling of discomfort and tenderness on pressure, and severe "neuralgia" is often complained of   The nodule becomes gradually absorbed in the course of days, or, more frequently, weeks,

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but during the process of absorption, or soon after, fresh nodules of the same type arise   In this manner the disease may drag on for months   Both eyes are frequently affected   In the worst cases the disease extends into the deeper parts of the sclerotic, and thus passes almost imperceptibly into sclentis

Anatomically dense lymphocytic infiltration of the subconjunctival and episcleral tissues is found

Rheumatism and gout are commonly indicated as the chief causes of episcleritis   A history of acute rheumatism is rarely obtained , more commonly there has been well marked "muscular rheumatism," which is to be ascribed to septic absorption (*vide* p 273)   Tuberculous or syphilitic patients seem predisposed, and almost invariably there is some cause of general debility   It is commonest in elderly people (cf *Sclentis*), and in women

Treatment   General treatment is of more avail than local   Even in cases in which no history of rheumatism can be elicited, salicylate preparations—salicylates, aspirin—seem to do good and should be tried   If they fail resort should be had to iodides   Diaphoresis by pilocarpine injections and vapour baths does good in some cases, and inunctions of mercury are useful independent of syphilitic infection

The most useful local treatment is massage by the finger applied to the upper lid   A simple boric ointment may be used or a weak yellow oxide of mercury ointment, but strong stimulants can rarely be borne   In the more severe cases warm compresses, dionin, and leeches to the temple should be employed   In the worst cases the constant current, scarification or superficial cauterisation are indicated   Every effort must be made to build up the constitution, and success often depends upon these measures

Sclentis is rarer than episcleritis   There are usually nodules, or a single nodule, but the area affected is much less circumscribed   The swelling is at first dark red or bluish, later it becomes pale purple and semitransparent, like porcelain   It may extend entirely round the cornea, forming a very serious condition known as *annular sclentis*   Sclentis differs from episcleritis in that the cornea and uveal tract are involved, some iritis, but more cyclitis and anterior choroiditis being present   There is no ulceration, but much absorption, so that the sclerotic is thinned, a dark purple cicatrix being formed, which is often too weak to withstand the intraocular pressure, so that ectasia follows (*ciliary staphyloma*)   In many

cases of diffuse deep sclerttis hard whitish nodules develop
in the inflamed zone   They are the size of a pin's head and
lie beneath the conjunctiva, all at about the same distance
from the corneal margin   they disappear without disintegrating

Anatomically sclerttis is the same as episclerttis, but extends
deeper, there is dense lymphocytic infiltration of the sclera,
the lamellæ being separated by cords of cells

Both eyes are usually affected   Young adults are the most
common subjects (cf Episclerttis), and women more often
than men   The causes are obscure, but of the same type as
in episclerttis   It is often associated with disturbance of
menstruation

Sclerttis is most serious on account of its sequelæ and complications Uveitis of some kind is
probably an invariable accompaniment   It is uncertain whether it
may be a result or a cause of the
sclerttis, most probably it is
neither, but both are due to a
common cause   This cause is probably the absorption of toxins from
some septic focus   It is often difficult or impossible to find the focus,
but special attention should be
directed to the nasal sinuses and

Fig 151 —
Sclerosing kerat is
(After Nettleship)

generative organs, the latter especially in women   In other
cases the alimentary canal is probably at fault, and many of
the drugs which have been found beneficial probably act
chiefly by disinfecting the intestinal tract   In some cases
the disease is undoubtedly tuberculous and in others syphi
litic   Stock has produced sclerttis sclerosing keratttis and
lesions in the uveal tract by the intravenous injection of
tubercle bacilli in rabbits   There is little doubt that tubercle
plays a larger part in disease of these structures in man than
has hitherto been recognised   Ciliary staphyloma leads to
distortion of the globe, and vision is impaired by it and by
the many deleterious effects of the uveitis   Secondary
glaucoma often follows

Apart from these complications sclerttis nearly always
extends to the cornea, causing *sclerosing keratttis* (Fig 151)
An opacity develops at the margin of the cornea near the
sclerotic nodule   It is approximately triangular or tongue-
shaped, the rounded apex being towards the centre of the

cornea Similar opacities may develop farther from the margin and even at the centre The opacities are grey or greyish yellow, *becoming denser until they exactly resemble the sclerotic*—hence the name They are indeed due to changes in the substantia propria, which is embryologically a specially differentiated part of the sclerotic There is little or no vascularisation and ulceration never occurs Some clearing from the centre towards the periphery, as well as near the marginal corneal loops (*vide* p 241), occurs, but the densest parts usually persist as bluish clouds The whole margin of the cornea may become opaque like the sclerotic, but the pupillary area almost invariably escapes

Treatment is the same as for episcleritis When tubercle is suspected injections of tuberculin may be employed Dionin and subconjunctival injections of saline, &c, have been recommended Uveal complications must be treated with atropine, &c (*See Chapter XIII*) Ultraviolet light some times has a good effect on sclerosing keratitis and good results have followed administration of vitamin C (*vide* p 230)

Gumma of the Sclerotic is uncommon It may be indistinguishable in appearance from scleritis, or it may take the form of nodules of various sizes, situated near the limbus, extending backwards to the equator or even giving rise to an annular scleritis Gumma may spread to the interior of the eye or a gumma of the ciliary body may spread outwards and involve the sclerotic Unless active antisyphilitic treatment is adopted early and carried out thoroughly the eye is very likely to be lost from uveal complications, ciliary staphyloma, or phthisis bulbi

The diagnosis depends upon the history, co-existing signs of syphilis, and the application of the Wassermann test

Tubercle of the Sclerotic may take the form of a scleritis, may be an extension from the conjunctiva iris, ciliary body, or choroid, or may be primary, forming a localised nodule which caseates and ulcerates It should be excised or scraped and the tissue examined for tubercle bacilli

Annular Scleritis, as already mentioned may be a form of ordinary scleritis or of gummatous scleritis A severer type is sometimes known as brawny scleritis and is characterised by a brownish red gelatinous looking swelling surrounding the cornea and extending back towards the equator It generally occurs in old people and is fortunately rare, for it is little amenable to treatment Some cases but not all give a positive Wassermann reaction

Ulceration of the sclerotic is always secondary, either from without or from within   Extension from the conjunctiva is almost always due to tuberculous ulceration, rarely syphilitic   Extension from within is almost always from the iris or ciliary body and is usually tuberculous in the case of the iris, syphilitic in that of the ciliary body   Ulceration of malignant growths which have perforated the sclerotic also occurs—sarcoma of the iris or ciliary body, glioma of the retina   All these conditions are rare

Blue Sclerotics   The sclerotic is bluish in babies, but a much more pronounced blue coloration is sometimes seen in several members of the same family as an hereditary condition, and persists throughout life   A curious and hitherto unexplained feature of these cases is that the patients in many of the families are also suffer from fragilitas ossium   The sexes are about equally affected ; only those affected can transmit the disease   In a case examined microscopically the sclerotic was about one third the usual thickness ; the cornea was also thin and Bowman's membrane was absent

CHAPTER XIII

Diseases of the Iris and Ciliary Body

THE uncouth term *uveitis* has the merit of emphasising an important fact, viz, the close relationship which exists between the anatomically distinct parts of the uveal tract   It draws attention to the frequency with which inflammatory processes involve the tract as a whole, and are not strictly limited to a single part   This feature is particularly well exemplified in inflammation of the iris and ciliary body   Probably iritis never occurs without some cyclitis, nor *a fortiori*, cyclitis without some iritis   The disease is called iritis or cyclitis according as the iris or ciliary body appears clinically to be the more affected   The same disposition is also seen with regard to the choroid, though in less degree   General uveitis is commonest in the more chronic types of inflammation, but it is probable that the ciliary body is often involved in many cases which we are accustomed to regard as pure choroiditis

For convenience of description it is best to consider diseases of the various parts of the uveal tract separately, but the anatomical, physiological and pathological continuity of the parts can be scarcely too forcibly insisted upon

INFLAMMATION OF THE IRIS AND CILIARY BODY

Iritis   In order that iritis and the special dangers which attend it may be thoroughly understood, it is necessary to remember the anatomical arrangements of the iris and the pathological changes which occur in it   The iris is practically a diaphragm of blood vessels and unstriped muscle fibres held together by a very loose, spongy stroma   In its perpetual movements the pupillary margin slides to and fro upon the lens capsule   The more the pupil is constricted the more of the posterior surface of the iris is in contact with the lens capsule, when fully dilated the iris probably does not touch the lens at all

Inflammation of the iris is fundamentally the same process as occurs in other connective tissues   it consists in dilatation

of the blood vessels, impairment of the capillary walls, exudation of a highly albuminous lymph into the tissue spaces and leuco or lympho cytosis Owing to the extreme vascularity of the iris and the peculiar distribution of the vessels, and to the looseness of the stroma, these generic features of inflammation produce special results Thus, simple hyperæmia tends to cause the pupil to contract mechanically, on account of the radial disposition of the vessels This is to some extent physiological, but is greatly increased under pathological conditions The extreme vascularity and the looseness of the tissues causes an unusually large amount of exudation on the one hand and of swelling on the other Owing to the greater albuminous content of the fluid its viscosity is increased so that it escapes into the anterior chamber and out of the anterior chamber by way of the filtration angle (vide p 20) with greater difficulty The iris, from being a partially wrung out flat sponge, becomes a sponge full of sticky fluid Hence its freedom of movement is greatly impaired, and the normal reactions become very sluggish or completely abolished The fluid, too, contains deleterious substances which act as irritants, the nerve endings are stimulated so that the muscle fibres contract In any case in which the sphincter and dilatator fibres are equally and uniformly stimulated the sphincter overcomes the dilatator, so that constriction of the pupil follows

It is easy now to understand the chief signs of iritis The pupil is constricted, partly owing to hyperæmia, partly to irritation, the edge of the pupil is markedly irregular The reactions of the pupil are sluggish, partly owing to the same causes which induce constriction partly to what may be termed water logging The latter condition causes an alteration in the appearance of the iris The delicate iris pattern, instead of being clear and sharply defined, becomes blurred and indistinct (' muddy ' iris) The colour undergoes considerable change, varying according to the condition of normal pigmentation In fair people with little pigmentation, the blue iris becomes bluish or yellowish green, brown irides show less difference but become greyish or yellowish brown In any case comparison of the colour of the two irides will usually reveal some slight difference, for iritis is generally unilateral during the acute attack

As a result of the change in colour and blurring of the iris pattern the hyperæmia of the iris itself is not very obvious, but it manifests itself in circumcorneal ciliary congestion (vide

p 20) This is most marked if the ciliary body is seriously involved, but the conjunctival vessels are also frequently somewhat engorged, so that care is necessary in distinguishing the condition from conjunctivitis The secondary nature of the conjunctival congestion is shown by the relatively slight discharge what discharge there is is chiefly lacrymal, never mucopurulent in the absence of actual conjunctivitis as a complication

The iris is richly supplied with sensory nerves from the ophthalmic division of the fifth nerve It is not surprising, therefore that pain is a prominent symptom of acute iritis It is not confined to the eye, though severe neuralgic pain is felt here, but is also referred to other branches of the first division of the fifth nerve, especially to the brow and parts supplied by the supraorbital and trochlear branches, but also to the cheeks and malar bone, and sometimes to the nose and teeth It is worse at night

The albuminous exudates escape slowly into the anterior chamber and mix with the normal aqueous If the ciliary body is much involved the aqueous itself is plasmoid (*vide* p 21) The aqueous often contains leucocytes and minute flakes of coagulated proteid, seldom fibrinous networks except in severe cases It therefore becomes hazy, further inter fering with a clear view of the iris and easily mistaken for haziness of the cornea, which is usually not involved In very intense cases, especially of traumatic iritis with septic infection, large numbers of polymorphonuclear leucocytes are poured out , these sink to the bottom of the anterior chamber and form an hypopyon Hypopyon is rare in simple iritis without perforation of the globe Hyphaema, or blood in the anterior chamber, may also occur, but is rare in simple iritis

The abnormal condition of the aqueous impairs the nutrition of the endothelium which covers the back of the cornea The cells become sticky and may desquamate in places The exudates tend to stick to the more affected spots, forming *keratic precipitates* ("keratitis punctata") These are seldom present in simple iritis, but form an important feature of cyclitis, varying roughly with the amount of cyclitis present

The more albuminous the aqueous the more viscous it becomes This viscous fluid filters out of the anterior cham ber by the filtration angle with difficulty Hence there is a tendency for the fluid to be retained, so that the intraocular tension rises The rise is minimal and of no serious import in cases of simple iritis—in fact, it is scarcely appreciable by

clinical methods If, however, the ciliary body is much involved, the albuminous constituents of the aqueous are very markedly increased, and rise of tension may be so great as to endanger the sight requiring special attention

The exudates which are poured out by the iris and ciliary body are naturally most concentrated in their immediate neighbourhood They cover the surface of the iris as a thin film and spread into and often completely over, the pupillary area In this manner the pupil may become " blocked " with exudates, a condition which very seriously impairs the sight of the eye Moreover, the exudates tend to stick the iris down to the lens capsule, so that it becomes immovably fixed

If the patient is seen in the early stages and atropine is instilled the pupil dilates, though not so readily as a normal pupil, on account of the water logging of the iris By con

Fig 152 — Diagram of seclusion and occlus on of the pupil with bowing forwards of the iris (iris bombé) (Nettleship)

tinuous treatment the iris may be freed from the lens capsule and the pupil become completely dilated and circular

The exudates, however, show a great tendency to become quickly organised This is particularly seen in most cases of iritis, less frequently in cyclitis, when it is a very marked feature of the case the inflammation is often described as plastic If the exudates which bind the iris to the lens capsule have not been already broken down they may become converted into fibrous bands which atropine is wholly unable to rupture Such firm adhesions of the pupillary margin to the lens capsule are called *posterior synechiae* (συνεχειν, to hold together) When they are present a mydriatic causes only the intervening portions of the circle of the pupil to dilate and the pupil assumes a festooned appearance (Plate VI , Fig 4 , Fig 156) Even in the absence of a mydriatic minute inspection will generally show irregularities of the pupillary margin due to the synechiae Such an irregular pupil is a sign of present or ⸻ iritis For diagnostic purposes homatropine should be ⸺ed and the result confirmed by the appearance of the ⸺ pupil (*vide* p 260) Owing to the contraction of ⸺ ⸺ exudates upon the surface of the iris the retinal pattern ⸺ ⸺helium may be pulled outwards over the pupillary but it man⸺ ⸺hes of pigment are then seen in this situation

(ectropion of the uveal pigment)   Posterior synechiæ show
some predilection for the lower part of the pupil in the early
stages   probably owing to gravitation of the plastic exudates
   In very severe cases of plastic iritis, or after recurrent
attacks, the whole circle of the pupillary margin may become
tied down to the lens capsule   The condition is called *annular*
or *ring synechia* or *seclusio pupillæ* (Figs 152 155)   it is one
of great danger to the eye (*vide* p 269)   In similar cases,
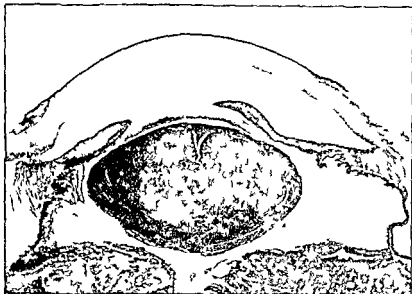
Fig 153 —Total posterior synech a (× 7) from a case of plastic ir do
   cyclitis beginning to cause phth s s bulbi   Tl e iris is completely
   adherent to the lens capsule and the periphery is retracted   There
   is a delicate inflammatory pup llary membrane (occlusio pup llæ)
   There is also an anterior capsular cataract due to inflammat on
   it conta ns calcareous deposits as shown by the patch of dark staining
   The ciliary body is degenerated and detached from the sclerot c at
   the posterior part   The retina is completely detached and folded
   behind the lens

especially if the case has been neglected and the pupil not
well dilated by atropine at an early stage the exudates in the
pupillary area may also organise   A film of opaque fibrous
tissue then fills the pupil, this condition is called blocked
pupil, or *occlusio pupillæ* (Figs 152 155)   If there has been
much cyclitis the posterior chamber (Fig 1) also becomes filled
with exudates which may organise   They then tie down the
whole of the back of the iris to the lens capsule , this condition

is called *total posterior synechia* (Fig 153) It leads to retraction of the peripheral part of the iris, so that the anterior chamber becomes abnormally deep at the periphery, sometimes much deeper than in the centre

Iritis is most frequently mistaken either for conjunctivitis or for acute glaucoma The points which distinguish it from conjunctivitis will be gathered from what has already been described The error of mistaking iritis for glaucoma is the most serious which can be made, more particularly because the treatment of the two conditions is diametrically opposed Dilatation of the pupil with atropine, which is urgently necessary in iritis, is the worst possible treatment of glaucoma (*q v*) At the cost of some repetition, the distinguishing features will be given here

(1) In iritis the pupil is smaller than normal and irregular, in glaucoma it is larger and oval, usually with the long axis vertical

(2) In iritis the intraocular tension is scarcely appreciably raised unless much cyclitis is present, in glaucoma it is always appreciably raised, and is often very high

These are the two chief objective signs Cases occasionally arise which are doubtful even to the most experienced A useful and harmless procedure which will almost invariably settle the question is the following A drop of 2 per cent euphthalmine or homatropine (*not* atropine) solution is instilled As the pupil dilates, in iritis the irregularities are emphasised and synechiae are almost always revealed, the tension is not appreciably affected by the mydriatic, in glaucoma the pupil probably dilates slowly but quite evenly, retaining its roundness, the tension is appreciably increased by the mydriatic As soon as glaucoma is definitely diagnosed by this test eserine (1 per cent) must be *immediately* instilled and repeated at intervals (*vide* p 291) Atropine is never to be used for diagnostic purposes, since eserine is incapable of counteracting its mydriatic effect and if the case were found to be one of glaucoma immediate operation would be imperative

(3) The subjective symptoms differ in the two diseases Vision is usually more impaired in glaucoma than in iritis In acute glaucoma the onset of the pain is sudden, and it is so severe that it is frequently accompanied by vomiting

It will be advisable again to enumerate the chief symptoms and signs of iritis The subjective symptoms are pain, of a neuralgic character, referred not only to the eye but also to the

supra orbital region, dimness of vision, due to cloudiness of the aqueous, exudates in the pupillary area, &c   The objective signs are   constriction and irregularity of the pupil unless a mydriatic has already been instilled, in which case the irregularity is emphasised by the presence of the posterior synechiæ   If the mydriatic is instilled early these synechiæ may break down so that the pupil again becomes quite round, in such cases spots of lymph or pigment upon the anterior capsule of the lens often leave permanent marks of old synechiæ, and form most valuable evidence of previous iritis (Fig 154)   It has already been pointed out (p 4) that the posterior layer of the retinal pigment epithelium on the back of the iris is less firmly attached to the iris than the anterior   When a synechia breaks down some of the posterior layer often tears away and remains attached to the lens capsule   these pigmented spots never disappear entirely   They are easily distinguished from the congenital spots due to persistence of the pupillary membrane pigment (*vide* p 277), and are valuable evidence of previous iritis   Discoloration or muddiness of the iris, whereby the iris pattern is masked, hyperæmia, manifesting itself chiefly as circumcorneal ciliary congestion   exudations, manifesting themselves either as more or less cloudiness of the aqueous or as solid deposits in the pupillary area and upon the iris   these are conspicuous signs of inflammation of the iris

Fig 154—Spots of pigment on the lens capsule left by posterior synechiæ which have broken down (Nettleship)

The course of iritis varies with its intensity   Even the slighter acute cases take three or more weeks before inflammation entirely subsides   The best sign is the prompt action of atropine, for in the worst cases it has little or no effect   Improvement is shown by good dilatation, diminution of injection and pain   In the chronic cases the ciliary body is almost always more seriously involved, the condition is one of irido-cyclitis   The inflammatory signs are less, but diminution of vision is progressive, and the disease not infrequently lasts for years

One of the most characteristic features of iritis and cyclitis is the great tendency to relapse   It depends not upon the synechiæ, as was once taught, but upon the constitutional *cause* of the disease   Each fresh attack runs a similar, though usually less severe, course, often leaving fresh traces and increased impairment of vision

Complete resolution may occur in slight cases treated early

and suitably The exudates become absorbed, the synechiæ
break down, leaving only such slight traces that vision may be
perfect Comparatively slight cases may, however, leave very
serious results if they are improperly treated, and in severe
cases these are the rule Most of the evil results are attribu
table to neglect of or impossibility of early dilatation of the
pupil, which causes permanence of the posterior synechia If
these are few, no special injury or impairment of sight follows,
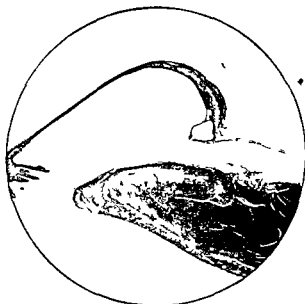
FIG 155 —Iris bombe with very broad peripheral anter or synechia
annular posterior synechia (seclus o pupillæ), and inflammatory
pup llary membrane (occlus o pupillæ) There is also an anterior
capsular cataract

but future attacks are more likely to result in an increased
number or in ring synechia

Ring synechia, or seclusio pupillæ, is one of the worst
sequels of the disease, since, if unrelieved, it inevitably leads to
secondary glaucoma and destruction of sight Owing to the
complete shutting off of the pupil the aqueous is unable to pass
forwards into the anterior chamber, the pigment epithelium
forming a non permeable membrane It therefore collects
behind the iris, which becomes bowed forwards like a sail, a
condition which is called *iris bombé* (Fig 155) Regarded from
in front, the anterior chamber is seen to be funnel-shaped,

deepest in the centre and shallowest at the periphery The filtration angle is obliterated by the adhesion of the iris to the cornea and sclera at the periphery (peripheral anterior synechia) Hence the fluid is retained within the eye and the intraocular tension rises (*vide* p 280)

Organisation of the exudates in the pupillary area leads to the formation of an inflammatory pupillary membrane or occlusio pupillæ This interferes directly with the transmission of light rays and is often associated with ring synechia, with or without total posterior synechia (*vide* p 259) In such cases there is generally plastic cyclitis and the eye is irretrievably affected

Repeated attacks of iritis lead to atrophy of the iris, which becomes dirty grey, like felt or blotting paper Red streaks often mark the site of permanently dilated vessels, usually of new formation and therefore not necessarily radial in direction The pupillary margin is thin and frayed, the reactions are diminished

Varieties of Iritis The varieties of iritis are usually divided into primary and secondary, the latter being those which are due to extension of inflammation from some other part of the eye, usually the cornea The primary iritides are due to some general dyscrasia, though it is not always possible to determine its exact nature (so-called idiopathic iritis) The most undoubted cause is certainly syphilis ; other causes are gonorrhœa, tubercle, and diabetes There is both clinical and experimental evidence that certain strains of streptococci have a specific selectivity for the tissues of the uveal tract Alleged causes are gout, "rheumatism," acute exanthemata, &c Finally, iritis is usually an important element of sympathetic ophthalmia (q v)

Fig 156 — Plastic iritis with nodules in the angle of the anterior chamber (Nettleship from a drawing by Holmes Sp cer) The patient was not syphilitic

Syphilitic Iritis manifests itself in two forms Syphilis is the commonest cause of simple plastic iritis, which occurs in the secondary stage, soon after the skin eruptions, usually within the first year after infection, but not before the third month There may be nothing characteristic about this form of iritis, or nodules may occur upon the iris (*vide infra*) Syphilitic iritis lasts two to eight weeks and does not usually recur, thus differing from the "rheumatic" form

Iritis used to occur in at least 3—4 per cent of syphilitics, and of cases of iritis syphilis accounted for at least 25—30 per cent, but syphilitic iritis appears to be less common than formerly, probably owing to earlier and more thorough anti syphilitic treatment   Syphilitic iritis is generally unilateral, but the second eye becomes affected sooner or later in about a quarter of the cases   Iritis due to other causes is unilateral in only about 10 per cent   Syphilitic iritis attacks males more than females, and three fourths of the cases are between twenty and forty years of age   The Wassermann reaction is of great value in settling the diagnosis   The spirochæte has been found in the aqueous

Simple plastic iritis also occurs in congenital syphilis, usually as an accompaniment of interstitial keratitis (*q v*)   It also occurs in very young babies with congenital syphilis, without any corneal complication, but usually with large nodules or gummata on the iris   This is not common, but is probably the only cause of iritis in very young children apart from direct injury   It is sometimes seen so soon after birth that almost

Fig 157.—Nodules occurring in the secondary stage of syphilis situated at the pupillary border of the iris (Nettleship, from a drawing by W G Laws)

certainly in these cases it commences as an intrauterine inflammation   The average age of onset is five to six months   It is commoner in females than in males, and is unilateral in about half the cases (Hutchinson.)

The iris also becomes inflamed in some cases of acquired syphilis late in the secondary or very rarely during the tertiary stage   These cases are characterised by the formation of yellowish red nodules near the pupillary and ciliary borders of the iris but not in the intermediate region.   The nodules are usually multiple and vary in size from that of a pin's head upwards (Fig 157)   It has been customary to consider these nodules either condylomata or gummata, according to the stage of the complaint   There is no good ground, either clinical or pathological, for the distinction, and the term *gummatous iritis* may be used for all these cases   There is generally much exudation in gummatous iritis, and broad synechiæ are formed   The nodules are liable to be mistaken for tubercle (*q v*) or sarcoma (*q v*), the absence of iritis and the presence of only a single nodule usually distinguishes the

latter condition, which, moreover, is extremely rare Gummatous iritis may rarely extend to the corneo-sclera at the angle of the anterior chamber and lead to perforation of the globe

The sites of previous gummatous deposits in the iris are marked by depigmentation of the stroma, probably owing to stretching Whitish spots in the ciliary region of the iris, especially near the crypts, occur in the early stages of syphilitic infection without previous iritis Syphilitic degeneration of the vessels causes thickening of the coats, sometimes making them appear as white lines Atrophy of the muscle fibres, especially of the sphincter, also occurs, and a circle of atrophic patches near the pupillary border is strong evidence of syphilis

Vision is usually impaired permanently in syphilitic iritis, and the prognosis is worse in the gummatous type Specific iritis is indeed a sign of severe syphilis Trousseau found that thirty four out of forty patients ultimately developed grave sequelæ such as tabes and general paralysis

Gonorrhœal Iritis is probably more common than is generally supposed It occurs especially in those cases which have gonorrhœal "rheumatism" and seldom supervenes until after one attack of arthritis, usually in the knees It exhibits no special signs , it tends to recur, often during the onset of a gleet or arthritic attack There is little doubt that it is a metastatic infection The patients are almost always men, and as a rule both eyes are affected, though not at the same time Extension to the ciliary body may be indicated by fine vitreous opacities, but involvement of the choroid is very rare Another more characteristic form may occur during the acute attack The exudates into the anterior chamber then have a peculiar gelatinous appearance and a greenish grey colour which is characteristic

"*Rheumatic*" *Iritis* In patients with iritis, in whom no specific or gonorrhœal taint can be discovered, a history of rheumatic pains in the muscles and joints can often be elicited. Iritis seldom, if ever, accompanies an attack of acute rheumatism, and only rarely can a history of such an attack be obtained The patients are often gouty or have rheumatoid arthritis What the pathological relationship of the iritis is to these complaints must remain a matter of conjecture until their ætiology is placed beyond dispute It is most probable that both the "muscular rheumatism" and the iritis are due to a common cause, toxins derived from a septic focus in some part of the body, *e g*, mouth, nasal sinuses, intestinal tract,

&c   The iritis in these cases is usually a plastic iritis of moderate severity   It often attacks both eyes and shows a very marked tendency to recur, and the recurrence seems to bear a direct relationship to the recurrent attacks of pain or arthritis   There is often an unusual amount of conjunctival and episcleral congestion   Iritis in an elderly patient is likely to be gouty, often starting suddenly in the night and sometimes ushering in an acute attack of gouty arthritis

Diabetic Iritis is rare   it is probably a gouty iritis occurring in a diabetic subject (Nettleship)   It shows a marked liability to the formation of new or enlarged vessels in the iris, with the formation of plastic exudates and occasionally an hypopyon   On the whole it runs a favourable course

Tuberculous Iritis occurs in a miliary and a conglomerate or solitary form   In the former there is usually a yellowish white nodule surrounded by numerous smaller satellites , there is the same tendency as in gummatous iritis for the nodules to be near the pupillary or ciliary margins   In the earliest stages the nodules are minute greyish, and translucent   There are often spots of k p ' on the back of the cornea, indicating involvement of the ciliary body   Hyphaema is not un common,   and pseudo hypopyon, composed of caseating tuberculous material, may occur   In conglomerate tubercle there is a yellowish white tumour, though smaller satellites may be present   The nodules contain giant cells   There is usually less general iritis than in the gummatous form, but there is almost always some   The condition may be mistaken for gummatous iritis or for sarcoma   The absence of specific history, a negative Wassermann reaction, the failure of anti syphilitic treatment   and the age of the patients—children or young adults—are features distinguishing it from gummatous iritis   The presence of satellites the usual, but not invariable absence of visible vessels upon the surface of the nodules   the age of the patient, and the presence of iritis distinguish it from sarcoma   The diagnosis may be extremely difficult but the great rarity of sarcoma of the iris should be borne in mind   Simple iritis is said to be sometimes tuberculous

In conglomerate tubercle of the iris the corneo sclera at the angle of the anterior chamber almost invariably becomes ultimately eroded and involved   The wall of the globe is thus weakened and eventually gives way   The tuberculous mass then grows rapidly through the perforation, and a large por tion of the iris may become prolapsed   In this manner the eye is inevitably lost

von Pirquet's cutaneous reaction may be applied to doubtful cases A positive result is of little value except in children, but a negative result eliminates the diagnosis of tubercle with a fair degree of certainty Wolff Eisner or Calmette's conjunctival test should not be used on account of the danger of severe reaction Subcutaneous injection of Koch's old tuberculin gives a characteristic rise in temperature, &c , in the presence of tubercle, but there is no proof that the ocular lesion is the cause of the reaction, and the test is not free from danger, due to violent local reaction

Treatment Dilatation of the pupil with atropine and hot applications are the essentials of local treatment Atropine acts in three ways (1) by keeping the iris and ciliary body at rest , (2) by diminishing hyperæmia , (3) by breaking down posterior synechiæ and preventing the formation of fresh ones It may be used in the form of drops of a 1 per cent solution or as an ointment of the same strength I prefer the ointment for the following reasons (1) its action is more continuous, (2) it is easier to apply, since it usually works into the eye even if only rubbed along the lashes , (3) it is less likely to cause symptoms of poisoning which are not uncommon with the drops in children Symptoms of poisoning—dryness of the throat, flushing of the face, delirium, &c—are due to the excess of solution—often considerable in unskilful hands—passing down the nasal duct into the nose and throat The dose administered in this manner is never lethal

Atropine should be pushed in the early stages, best by frequency of application rather than increased strength Every four hours is usually sufficient When the pupil is well dilated, two or three times a day suffices If atropine irritation ensues, hyoscine, scopolamine, or duboisine should be substituted Dionin, 5—10 per cent , may be used in conjunction with the mydriatic

A very powerful mydriatic effect is obtained by the subconjunctival injection of 5 minims of mydricain (*vide* p 692), a mixture of atropine, cocaine, and suprarenin

Hot applications are extremely grateful to the patient diminishing the pain, and are of therapeutic service in encouraging a more vigorous blood and lymph flow Hot fomentations and bathings may be used, but dry heat applied to the surface of the closed lids has the same effect This may be done by means of medical diathermy (300 to 600 milliampères for five minutes) or an electric heater, which is bandaged over a pad of wool previously well heated and applied to the eye. By

this means the heat is considerable and continuous, with a minimum of trouble and discomfort

In very severe cases, or when the pupil does not readily respond to atropine, depletion of blood from the temple should be resorted to The best method is by two or three leeches applied a short distance outside the external canthus They should not be too far from the eye, nor too near, for in the latter case much œdema of the lids may follow Heurteloup's artificial leech may be used, but is not so efficacious, since the leech extract diminishing the clotting capacity of the blood has a beneficial effect

If the pain is very intense a hypodermic injection of morphia may be given Aspirin is very useful in relieving pain

General treatment should be commenced by a saline purge, and the bowels must be kept freely open throughout the acute stage

In other respects the general treatment depends upon the cause In syphilitic iritis the patient is rapidly got under the influence of mercury best by inunctions or the intramuscular injection of Lambkin's cream N A.B injections cause rapid improvement, but these cases also respond well to mercury These drugs are most effectual in the cases occurring during the secondary stage, but should also be used in the gummatous form Here they should be supplemented by iodides, but these must not be given simultaneously with injections of metallic mercury The infantile form of acute syphilitic iritis responds rapidly to mercury, but neither drug is very efficacious in the congenital type and in this, as well as in the later stages of the other forms, general tonic treatment is indicated

In gonorrhœal iritis gonococcic vaccine sometimes produces good results, and massage of the prostate, though it may cause a temporary exacerbation helps to remove the source of the trouble The administration of sulphapyridine (M and B 693) in full doses for fourteen days has produced good results (*vide* p 693) Vitamin C appears to be without effect

In other forms of iritis, where a rheumatic taint is suspected or where no satisfactory cause can be found, it is usual to order salicylic preparations, and they appear to do good, not only in these, but also in gonorrhœal and diabetic iritis An exhaustive search should be made for any septic focus in the body

In the convalescent stage smoked glasses are ordered—for both eyes, especially on account of the consensual reaction to light Atropine, or its equivalent, should be continued for

at least ten days or a fortnight after the eye appears to be quiet, otherwise a relapse is very likely to occur

Tuberculous iritis is treated by the same local applications as other forms The usual constitutional treatment must be pushed Improvement and even complete resolution have been recorded from the use of tuberculin injections, but they should be used cautiously, commencing with very small doses, since a violent reaction may have a serious effect upon the eye The dose is very gradually increased

Some authors consider that tuberculous iritis is generally the primary manifestation of the disease in the body. They therefore advocate the removal of the eye as soon as the diagnosis is made, in order that the danger of extension of the disease to other parts of the body may be minimised If perforation of the globe has taken place and the eye is irretrievably lost immediate excision should be urged, but in other cases ordinary treatment, supplemented by tuberculin should be persisted in. Good results have undoubtedly been obtained by the use of tuberculin, and it should be given a per severing trial, nevertheless it often fails to ameliorate the condition

Treatment of Sequelæ and Complications For the treatment of coincident cyclitis see p. 273

Firm posterior synechiæ can sometimes be broken down by placing a small particle of solid atropine in the conjunctival sac Care must be taken to prevent the dissolved atropine from passing down the nasal duct by pressure with the finger upon the lacrymal sac by the patient himself, but the surgeon must see that the pressure is rightly applied and kept up

Annular synechia demands an iridectomy in all cases in order to restore communication between the anterior and posterior chambers, and thus avoid the supervention of secondary glaucoma (*vide* p 280) In some cases it is necessary or advisable to be content with making a puncture or trans fixion of the iris by a broad needle No operative procedure of this kind must be undertaken during an acute or even the slightest attack of iritis if it can be possibly avoided since the traumatic iritis set up will frustrate the object of the operation by filling the coloboma with exudates and may even cause the loss of the eye It is best if possible, to forestall a ring synechia by performing the iridectomy before the adhesion extends round the whole circle This can often be done, because operable ring synechia, i e, ring synechia without total synechia, is frequently the result of recurrent attacks

of quiet or almost painless iritis, during each of which more of the circle is involved. The iridectomy is performed during a quiescent interval. It is often difficult to get a good coloboma owing to the atrophy and friability of the iris and the firmness of the adhesions. Hæmorrhage is common, and if for any reason operation on such an eye appears to be specially risky, particularly if it is an only seeing eye, the pupil should be kept continuously under atropine (0 5 per cent.) instilled once a day. Iridectomy sometimes has a beneficial effect on recurrent iritis, but should not be done without special indications
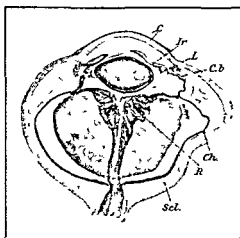
Fig. 158 —Phthisis bulbi, due to irido-cyclitis (× 3) *C,* cornea, *Ir,* iris ; *L,* lens; *C.b,* ciliary body, *Ch,* choroid ; *R,* retina, detached and folded up behind lens, separated from choroid by albuminous coagulum ; *Scl,* sclerotic

until all other non-operative measures have failed. The presence of "k.p." should generally be regarded as a contraindication to intraocular operation in the absence of dangerously high intraocular pressure.

Total posterior synechia can seldom be operated upon with success. Iridectomy is seldom possible, and the only procedure which can be adopted is extraction of the lens by a specially devised operation. Iridectomy or iridotomy may be possible if the lens is shrunken.

Cyclitis has already been referred to incidentally. In the severe *plastic* form the exudates from the ciliary body pass into the anterior chamber directly from that part which forms a

boundary of the chamber (Fig 2), and indirectly by passing forwards through the pupil When they organise they not only cause total posterior synechia, but also surround the lens and extend throughout the vitreous Behind the lens they form a transverse membrane or cyclitic membrane Strands of fibrous tissue are formed in the vitreous They become anchored to the retina in various places, and by their subsequent contraction often lead to detachment of the retina The exudates which organise upon the surface of the ciliary body cause the destruction of the ciliary processes, which results in abolishing or seriously diminishing the secretion of aqueous Hence the intraocular tension becomes lowered and the eye is quite soft to the touch The walls of the globe fall in, and the eye becomes shrunken and quadrilateral in shape owing to pressure by the recti muscles—*phthisis bulbi* (φθίνειν, to waste) (Fig 158) After this has occurred degenerative changes supervene, and the choroid becomes converted after months or years into bone

Chronic Irido-cyclitis (Syns —Simple Cyclitis, "Serous Iritis") is an extremely insidious and chronic disease, characterised by diminution of vision with slightly marked physical signs In severe cases there is ciliary congestion, tenderness on pressure over the ciliary region deep anterior chamber, precipitates ("keratitis punctata") on the back of the cornea and dust-like opacities in the vitreous Posterior synechiae are not a conspicuous feature, but are liable to be formed slowly and insidiously The tension is usually slightly raised in the earlier stages, lowered in the later There may be oedema of the upper lid and neuralgic pain in the eye and brow There is sometimes myopia, owing to irritation of the ciliary muscle

The *keratic precipitates* (k p') (Fig 159) consist of lymphocytes which are deposited from the aqueous upon the back of the cornea and stick there They may contain pigment granules, showing their origin from the uveal tract (pigmented k p) In the most characteristic form they are scattered over a triangular area of the lower part of the cornea, the smaller spots being above the larger below (Fig 159) This arrangement is due to gravitation of the particles towards

Fig 159 —Typical arrangement of the spots on the back of the cornea in keratitis punctata (k p) (Nettleship from a sketch by Dr Herring ham)

the bottom of the anterior chamber, combined with the per petual movements of the eye, which are mostly in the horizontal direction The typical arrangement is often but not always observed More commonly a few isolated spots are seen scattered irregularly over the lower part of the cornea They require great care in examination for their discovery (*vide* p 87), and their importance cannot be over estimated The smaller spots frequently coalesce, forming small plaques, which gradually become more translucent (' mutton fat k p ") Precipitates are generally sharply defined and can thus be distinguished from opacities in the deeper layers of the cornea They are more likely to contain pigment when the iris is brown, but " pigmented k p " also occurs with blue or grey irides if the inflammation lasts a long time Pigmentation therefore may give some indication of the duration of the disease The pigment persists almost indefinitely Similar precipitates are rarely seen upon the anterior capsule of the lens, but the leucocytes do not readily stick here owing to the smooth surface, devoid of endothelium

The vitreous opacities are of the same nature, viz , wander ing leucocytes, but many are also probably minute particles of albuminous exudate Their mobility in the vitreous shows that the consistency of this substance has undergone change, sometimes amounting to complete fluidity, due to defective nutrition

The increased depth of the anterior chamber is an important sign not easily explained It is undoubtedly connected with the deficient filtration of the plasmoid aqueous through the angle, which together with dilatation of capillaries produced by the secretion of histamine-like substances and axon reflexes, also accounts for the rise in tension The peripheral part of the anterior chamber is often particularly deep, even deeper than the central this is, however, more marked in the later stages of plastic cyclitis when it is due to mechanical retraction of the iris from organisation of exudates in the posterior chamber

In severe or prolonged cases the deeper layers of the cornea may become infiltrated, as in interstitial keratitis though seldom to the same extent This is specially liable to occur in tuberculous cases, and in these there are often minute greyish nodules on the surface of the iris These should be carefully looked for, as they are of considerable diagnostic significance, and the prognosis is correspondingly grave Tiny translucent nodules are sometimes seen, even in early stages, at the pupillary

margin of the iris These cases seem invariably to go from bad to worse in spite of treatment They are probably tuberculous

In the slightest and most insidious cases of irido cyclitis the symptoms and physical signs are minimal Considerable diminution of vision without obvious cause should always excite apprehension, and the cornea should be most carefully explored by oblique illumination with magnification by the loupe, as well as by the direct method with a strong convex lens A few spots of " k p " are decisive proof of cyclitis, and may be the sole physical sign Change in the colour of the iris, due to atrophy, is an important sign, since it may at once attract attention, especially if the normal eye has a brown iris It indicates, however, a late stage of the disease

Chronic irido cyclitis occurs under similar conditions to simple iritis and is commoner in women than in men Syphilis or tubercle may be the cause It is probably always due to some form of toxæmia or bacterial metastasis, and a careful search should be made for a septic focus in some part of the body. It is most frequently found in the mouth—pyorrhœa alveolaris—in the nose and accessory nasal sinuses, or, especially in women, in the genital tract The frequency of streptococcal bacteriæmia associated with pyorrhœa has been conclusively proved, the streptococci being usually of the viridans type—10 per cent of cases , 70 per cent immediately after extraction of teeth (Okell and S D Elliott) Very often no such source of toxins can be demonstrated, but the patients are usually of a debilitated type There is often constipation, and it is not improbable that the intestinal tract is a frequent source of the toxins

The disease is generally very chronic and liable to exacerbations with gradual and insidious formation of posterior synechiæ Vision is greatly diminished during the more acute stage, and recovers considerably in the intervals, but each recurrent attack leaves more and more permanent defect There is usually increased tension during the more acute stages, and thus may be so great as rapidly to abolish vision unless relieved The eye may finally become soft and tender, *and enter into the condition of phthisis bulbi, but this occurs* only after many years in simple cases of irido cyclitis Less serious cases however, not uncommonly occur, especially when the septic focus, e g , pyorrhœa alveolaris, is discovered and is amenable to radical treatment

Treatment of irido cyclitis is essentially the same as that of iritis, but special attention must be directed to any septic

foci which may be found and to the general health Septic foci such as pyorrhœa alveolaris, nasal, genital, or urinary sepsis, furunculosis &c, must be radically treated when possible If there is extensive pyorrhœa only four or five teeth should be removed at a time, since absorption of toxins from the gums may cause a severe exacerbation of the cyclitis and even alarming shock In some cases an autogenous vaccine has produced rapid cure, but more often it fails The cases often drag on indefinitely, with occasional exacerbations During the more acute phases energetic treatment with atropine, hot bathings or the electric heater, and if necessary blisters or leeches, is indicated Small doses of salol (gr ½, three times a day) or salol and salicylates do good in many cases of obscure ætiology, probably by acting as intestinal disinfectants Iodides help to cause absorption of vitreous and other exudates Hexamine has been recommended on theoretical grounds, but has proved disappointing In severe cases the patient should be kept in bed and submitted to mercurial inunctions or baths, which often do good in cases in which there is no specific history Diaphoresis by vapour baths and hypodermic injections of pilocarpine may be tried in intractable cases, which form the majority Cases of syphilitic or tuberculous origin, of course, require the appropriate methods of treatment, but tubercle should be used with great caution (*vide* p 269) Some cases, probably tuberculous, show marked improvement after a course of ultra violet radiation of the skin , the eyes should be carefully protected by suitable glasses (*vide* p 184) during the exposures Other cases are improved by protein shock (*vide* p 694)

If the intraocular tension is raised seriously, so that there is danger to the sight of the eye from this cause, it must be relieved by paracentesis (*vide* p 209) This usually has only a transitory effect, and may require to be repeated every two or three days It is theoretically unsatisfactory, since the comparatively sudden reduction of the intraocular pressure to zero causes dilatation of the ciliary vessels and allows the passage of a lymph which is even more albuminous than that which has been let out It should therefore not be resorted to unless imperatively indicated On the other hand, the final result is often very satisfactory, probably because the rapid flow of lymph flushes out the secretory channels and carries away endothelial and epithelial débris and stagnant toxins If repeated paracentesis fails to relieve the tension, an iridectomy may do good , it may be necessary to do a Herbert's

sclerotomy or an anterior sclerectomy (trephining), but this should only be done as a last resource, since the results are usually very disappointing

During the intervals between exacerbations the pupils should be kept moderately dilated with weak (0 5 per cent) atropine The patient should have plenty of fresh air, good diet, and tonics

If the eye becomes useless, shrunken, and painful it may be necessary to excise it

Plastic Irido cyclitis The pathology of this condition has already been described incidentally In it the signs of irido cyclitis in general are increased The cyclitic membrane behind the lens may be seen with the ophthalmoscope or even by oblique illumination In young children the condition forms one type of pseudo glioma (Chap XIX) In the later stages the degenerative changes in the ciliary body prevent it from fulfilling its functions of supplying the eye with lymph and nutriment The vitreous suffers first, becoming fluid, and later the lens, which becomes opaque Finally the eye shrinks (phthisis bulbi)

Treatment is the same as for chronic irido cyclitis The blind, shrunken globe is often painful and a continual source of annoyance to the patient It should in these circumstances, be excised

Gumma of the Ciliary Body causes an intense acute plastic irido-cyclitis with severe iritis much exudation into the anterior chamber, often deep infiltration of the cornea and usually great pain It is a rare complication of syphilis, not confined to the tertiary stage It varies in the severity of the symptoms and the rate of progress It is only to be diagnosed clinically with certainty when the inflammation extends into the sclerotic (*vide* p 253) If it does not respond to active anti syphilitic treatment, the eye eventually shrinks

Tubercle of the Ciliary Body occurs with tubercle of the iris and of the choroid, and is usually only to be inferred clinically rather than definitely diagnosed As already mentioned, the tubercle bacillus may account for some cases of chronic cyclitis

Uveoparotitis (*Syn —Heerfordt's Disease*) is a chronic bilateral parotitis and uveitis, generally occurring between ten and thirty years of age A low grade fever, sometimes accompanied by a rash like erythema nodosum, precedes or follows the swelling of the parotid There is frequently paralysis of the viith nerve, and other signs of peripheral neuritis, e g , ptosis, diplopia, recurrent laryngeal paresis, occur The parotid swellings may

last for six weeks to two years, but gradually subside Evidence of tubercle has been found in all cases examined histologically

An allied condition is *Bock's sarcoidosis* a low grade uveitis associated with nodules in the iris, cornea skin &c

Secondary Iritis See Chap XXI
Purulent Irido-cyclitis See Chap XXI
Sympathetic Irido cyclitis See Chap XXI

DEGENERATIVE CHANGES IN THE IRIS

Depigmentation of the iris is seen in old people and examination with the slit lamp has shown that disintegration of the iridic pigment is a constant senile phenomenon Depigmentation of the pupillary margin is common and may occur in the form of small triangular patches or radial fissures Irregular lacunæ in the retinal pigment may often be seen by transillumination, either by the slit lamp or by contact illumination Atrophy of the stroma especially near the pupil, is also common and the pupillary border may be frayed out and very irregular, independent of inflammatory changes

CONGENITAL ABNORMALITIES OF THE IRIS

One iris may have a different colour from the other, or parts of the same iris usually a sector, may differ in colour from the remainder Both conditions are known as *heterochromia iridis* The blue iris is due to the absence of pigment in the iris stroma, the pigment in the retinal epithelium being seen through the translucent stroma The eye with the lighter iris seems to be specially prone to iridocyclitis Many of these cases are due to wrong diagnosis, the lightness of the iris being due to degeneration *following* iridocyclitis , but this explanation does not account for all the cases (Fuchs)

Fig 160 — Congenital coloboma of the iris

Irides often have patches of brown pigmentation , these benign *melanomata* are due to abnormal groups of retinal pigment epithelium lying in the posterior layers of the stroma

The pupil is normally slightly to the inner side of the centre of the cornea In some cases it is considerably displaced, usually also to the nasal side—*corectopia* (κορη, pupil, ἐκ out of, τοπος, place) Rarely there are other holes in the iris besides the pupil—*polycoria*

The iris may be apparently absent—*aniridia* or *irideremia* Anatomical investigation has shown that there is always a

narrow rim persistent at the ciliary border, but it is hidden from view during life by the sclerotic   On examination the ciliary processes and the suspensory ligament of the lens can be seen   Aniridia is usually bilateral   There is a tendency for secondary glaucoma to develop in these eyes, a remnant of the iris blocking the angle of the anterior chamber

There may be a gap in the iris, usually pear shaped or like a Gothic arch continuous with the pupil and extending towards, but not always as far as, the ciliary border   It is called a *congenital coloboma* (*κολοβωμα* mutilation) of the iris (Fig 160)   It is usually downwards or down and slightly in, corresponding with the position of the fœtal   so called chorioidal cleft   such a coloboma is called typical   Colobomata are found in other directions, and are then atypical   Typical coloboma of the iris is often associated with typical coloboma of the choroid (*q v*), and in some cases with coloboma of the lens   It is one of the commonest congenital malformations of the eye

Persistent Pupillary Membrane is due to persistence of part of the anterior vascular sheath of the lens, a fœtal structure which normally disappears shortly before birth   Fine threads stretch across the pupil or may be anchored down to the lens capsule (Plate VI , Fig 3)   They are distinguished from post inflammatory synechiæ in always coming from the anterior surface of the iris just outside the pupillary margin   *i e*, from the position of the corona or circulus iridis minor   Such tags are of frequent occurrence and are of no pathological importance   They are commonest in babies and probably undergo further absorption as age advances but many persist permanently   Examination with the slit lamp shows that minute remnants of the pupillary membrane are very common even in adults

The fœtal pupillary membrane consists of a network of minute blood vessels supported by a very delicate stroma which contains pigment cells   Sometimes the pigment is left on the lens surface and persists   It forms a stippling of very fine brown dots scattered over a circular area 5 or 6 mm in diameter in the centre of the pupil   These spots are distinguished from pigment spots left by posterior synechiæ which have brol en down (*vide* p 261) in being much smaller, stellate in shape when magnified under the slit lamp   much more numerous and very regularly arranged, and also by the absence of any concomitant signs of iritis   They do not usually interfere appreciably with vision

Tumours and Cysts of the Iris

Tumours and Cysts of the Iris and Ciliary Body   See Chap XX

Cysts of the Iris   *Serous cysts* of the iris sometimes occur, and are due to closure of iris crypts with retention of fluid   *Cysts of the retinal epithelium* occur, due to accumulation of fluid between the two layers of retinal epithelium   They look like a bombé iris limited to parts of the iris—a limitation which is impossible in the case of true bombé iris (*q v*)   In these cases the posterior layer of epithelium is often adherent to the lens   *Implantation of epithelium* on the iris sometimes occurs after perforating wounds or operations giving rise to pearl cysts or cholesteatomata   The epithelium may spread over the iris and line the whole anterior chamber, causing glaucoma   Many such cases are not true implantation cysts, but are due to downgrowth of epithelium from the conjunctiva occurring in badly healing wounds   Eyelashes are sometimes carried into the anterior chamber in perforating wounds and lodge upon the iris

CHAPTER XIV

Glaucoma

GLAUCOMA is a symptomatic condition, not a disease *sui
generis* The characteristic physical sign is increased intra-
ocular pressure It will be clear from the description of the
mechanism whereby the normal intraocular pressure is main-
tained (*vide* p 14) that increase may be due either to (1)
increased production of lymph associated with normal or
diminished outflow, or to (2) diminished outflow associated
with normal or increased inflow. Though the factors which
cause increased production of aqueous, such as increased
permeability of the capillaries, brought about by the presence
of histamine like substances and by axon reflexes, cannot be
eliminated, yet it is probable that pathological increase of
tension is generally due to defective outflow It is probable
that in some cases the vitreous plays a preponderant part,
but the rationale must remain speculative until our knowledge
of the properties of the vitreous gel is further elucidated

Two great classes of cases in which the tension is pathologi-
cally increased can be distinguished, viz _-(1) those in which
the tension is only moderately increased, in which the anterior
chamber is deep, and in which there are more or less definite
signs of inflammation of the ciliary body (Chap XIII) , and
(2) those in which all grades of increased tension are met with,
in which the anterior chamber is shallow, and in which, though
there may be very evident signs of congestion and irritation,
any definite signs of ciliary inflammation are either absent
or secondary in onset It is well to keep these two groups
quite separate, since their pathogenesis is different and the
differences in clinical course and treatment are marked The
term glaucoma should be limited to the second group

True glaucoma may be conveniently divided into two forms,
primary and secondary. Since the pathology of secondary
glaucoma has been fairly well elucidated and throws some light
upon that of primary, the former will be considered first

Secondary Glaucoma We have seen that the increased
tension of irido-cyclitis can be explained by defective filtration
of the aqueous at the angle of the anterior chamber owing to

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the viscous nature of the fluid, though capillary dilatation may play a part (*vide* p 17) Secondary glaucoma is almost invariably associated with mechanical obstruction at the same spot Usually the obstruction takes the form of adhesion of the iris to the back of the corneo sclera This peripheral anterior synechia causes the obliteration of the network of the ligamentum pectinatum iridis, and prevents the fluid from gaining access to the canal of Schlemm It is therefore imprisoned within the eye and the intraocular pressure rises In order that this may occur it is necessary that the angle should be obliterated over a considerable part of its circumference, but there is a great tendency in most cases for the cause which has produced partial peripheral anterior synechia eventually to complete the circuit In some cases in which secondary glaucoma supervenes there is no actual synechia, but the meshes of the ligamentum pectinatum are choked with leucocytes, pigment granules, fibrin, &c , so that filtration is inefficient

Though peripheral anterior synechia seems definitely to be the immediate cause of secondary glaucoma, it is itself produced by a variety of conditions, most of which are various forms of anterior or posterior synechia

When an anterior synechia is formed the plane of the iris is advanced, so that the angle of the anterior chamber on this side is made more acute than normal The cause which led to the formation of the synechia also causes iritis usually of the traumatic type Traumatic iritis is merely a plastic iritis due to injury In it much exudation is poured out, possessing great tendency to organise It collects in the diminished angle and becomes transformed into fibrous tissue, which welds the iris and corneo sclera together, thus producing a peripheral anterior synechia, which may be strictly localised, so that no secondary glaucoma supervenes Such eyes, however, are liable to fresh attacks of iritis, often of an insidious character Each attack is followed by further occlusion of the angle, until finally the amount remaining open is insufficient to carry out efficient filtration and the pressure rises

The chief causes of secondary glaucoma are the following

(1) *Perforation of the cornea with anterior synechia* The perforation may be due to an ordinary perforating wound of the cornea with incarceration of iris in the scar, or it may be due to a perforating corneal ulcer The wound may be due to an operation, *e g* , extraction of cataract, for a peripheral section through the corneo scleral margin or actually in the sclero

PLATE VIII

Fol ff   e t

F o   --lt and L upped d s p   ry glau oma
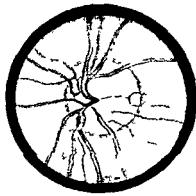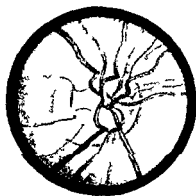
PLATE IX
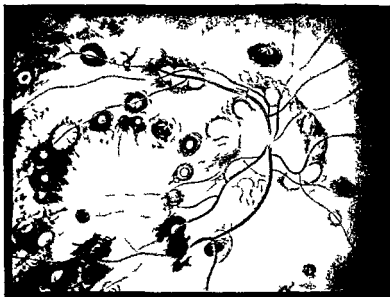
Fig 1 —Disseminated choroiditis
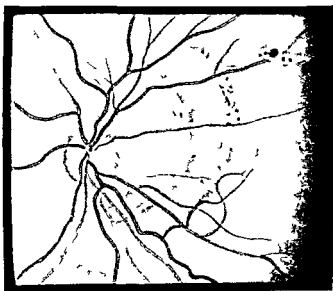
Fig 2 —Ruptured choroid

tic near the margin has a similar effect to a wound in the cornea
The synechia need not necessarily be of iris, but after cataract
extraction is often one of the lens capsule, which has the same
effect of advancing the contiguous parts of the iris and obliterat-
ing the angle   Secondary glaucoma after operations may also
be due to other causes (*vide* p 502)

(2) *Annular posterior synechia* (*vide* p 259)   This acts by
interposing an impermeable barrier between the posterior and
anterior chambers   The lymph secreted by the ciliary body is
thus prevented from passing forwards into the anterior chamber
The iris becomes bowed forwards—bombé—and the periphery
becomes apposed to the corneo sclera, where it later becomes
adherent   The aqueous is thus unable to escape from the eye
and the tension rises   If the condition is not relieved by opera
tion secondary glaucoma causes blindness   The prolonged
high tension then causes degeneration of the ciliary processes,
which cease to produce so much fluid, so that finally the tension
may be normal or even sub normal, and the eye may shrink.
The condition is relieved by iridectomy, or if this is impossible,
by iridotomy, communication between the posterior and
anterior chambers being thus restored

(3) *Wounds of the lens*   When the lens is wounded it swells
(*vide* p 446), and pushes the iris forwards into contact with
the corneo sclera   Moreover the swollen lens matter in the
aqueous impedes filtration through such part of the angle
of the anterior chamber as remains open, both mechanically
and also by increasing the albuminous content of the aqueous
Mere apposition is sufficient to produce permanent secondary
glaucoma, which should at once be relieved by operation (*vide*
p 446)   If it is not performed the iris becomes adherent to the
corneo sclera and the glaucoma becomes permanent, although
the lens eventually may be absorbed

(4) *Dislocation of the lens*   This may be complete through
the pupil into the anterior chamber   It then blocks the angle,
especially if the iris is firmly contracted against its posterior
surface   Partial lateral dislocation of the lens causes it to push
forwards the iris on the side towards which it is dislocated
Since the circle of the equator of the lens is not much smaller
than that of the angle a considerable portion of the latter may
be blocked, and secondary glaucoma supervenes

(5) *Intraocular tumour*   The mechanism whereby this pro
duces secondary glaucoma will be described later (*vide* p 420)

(6) *Intraocular hæmorrhage*   Severe intra-vitreous or sub-
choroidal hæmorrhage forces forwards the vitreous and lens,

so that the iris is pushed into contact with the cornea. It also acts by filling the eye with highly albuminous fluid which filters with difficulty. If the vessel which has ruptured is large the tension may be raised to that of blood pressure.

A special type of glaucoma is sometimes met with after retinal hæmorrhage, which may be due to some unknown cause or to thrombosis of the central vein (*q.v.*). It is probably caused by mixture of the lymph with albuminous fluids. Such cases are sometimes grouped together under the designation *hæmorrhagic glaucoma*, a term which is however best avoided. They
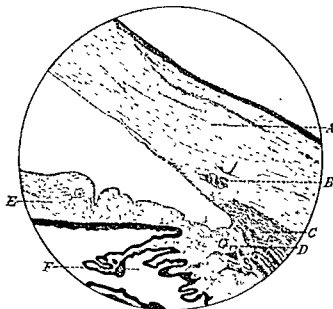
FIG. 161.—Normal angle of anterior chamber.

may be indistinguishable from primary glaucoma if not seen until the media are too opaque for ophthalmoscopic examination. Iridectomy is likely to be accompanied by severe hæmorrhage, and is therefore contra-indicated.

Primary Glaucoma. The cause of primary glaucoma is unknown. An attractive theory is that of Priestley Smith, who attributes the preponderant *rôle* to the lens. It has already been pointed out (*vide* p. 9) that the lens continues to grow throughout life. The space between the equator of the lens and the ciliary processes, the circumlental space, will therefore become smaller as the patient becomes older. If the

eye is small the space may become so diminished that slight
congestion of the ciliary processes may bring them in contact
with the lens. The effect will be to prevent the fluid which is
secreted by the ciliary body from passing forwards through the
pupil. The lens will therefore be forced forwards, and will push
the iris in front of it, making the anterior chamber very shallow,
and bringing the periphery of the iris in contact with the
corneo-sclera. In this manner the filtration angle will be
occluded and glaucoma will supervene. If the condition per-
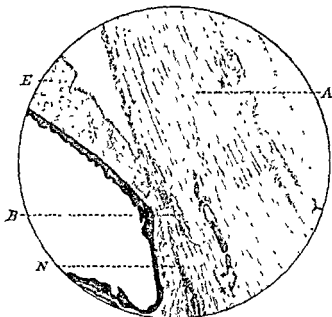
FIG. 162.—Peripheral anterior synechia (*N*), causing blockage of the
filtration angle. *A*, cornea ; *B*, canal of Schlemm ; *E*, iris.

sists an acute attack of glaucoma is caused. If the occlusion of
the angle is not complete a subacute attack is caused, and the
spontaneous diminution of the congestion of the ciliary body
may relieve the condition. The onset of fresh congestion leads
to another attack, and thus chronic glaucoma is brought about.
It will be seen from what follows that the facts often fit in very
well with this theory.

Primary glaucoma is essentially a disease of late adult or
advanced life. It usually occurs after fifty years of age and
is very common in Jews. It is sometimes hereditary, and in
these cases affords examples of " anticipation " (Nettleship),

ı e it occurs at an earlier age ın each succeeding generatıon
It ıs commoner ın women, *who are more lıable to venous*
congestıon ın varıous parts of the body Hypermetropıc eyes
are more susceptıble than those wıth normal or myopıc refrac-
tıon , ın fact, prımary glaucoma ıs uncommon ın myopıc
eyes Thıs has been shown to be due not to the hyperme-
tropıa *per se*, but to the smallness of the eyes In order that
an eye may be hypermetropıc ıt ıs not necessary for ıt to be
small, but as a matter of fact hypermetropıc eyes usually are
small It has been found that the sıze of the cornea ıs a good
crıterıon of the sıze of the rıng formed by the cılıary processes
ı e, of the cırcumlental space The sıze of the lens varıes
lıttle ın dıfferent eyes of patıents of the same age It follows,
therefore, thıt an eye wıth a small cornea wıll probably have a
small cırcumlental space, and wıll be very lıable to glaucoma

As age advances the anterıor chamber becomes shallower
Thıs wıll have the effect of dımınıshıng the sıze of the angle of
the anterıor chamber, and stıll more so ıf the cornea ıs small
Fıltratıon ıs carrıed out less easıly when the meshes of the
lıgamentum pectınatum ırıdıs are crowded together than when
they are wıdely separated Moreover the fıbres of the lıga
mentum pectınatum tend to become thıckened and sclerosed
ın elderly people In these eyes a very slıght further dımınu
tıon of the angle may brıng on an attack of glaucomı Thus
the mere dılatatıon of the pupıl wıth a mydrıatıc, by foldıng up
the ırıs so that ıt ıs crowded ınto the angle, may suffıce to
occlude ıt entırely , *hence the extreme danger of ınstıllıng a*
mydrıatıc ınto the eyes of elderly people, especıally ıf they are
hypermetropıc or have small corneæ and shallow anterıor
chambers Mere swellıng of the lens ın the early stage of
cataract (*vıde* p 307) may ınduce glaucoma ın eyes predısposed
to the dısease Although many of these elderly patıents have
arterıosclerosıs and abnormally hıgh blood pressure there ıs
no sıgnıfıcant correlatıon *between thıs and the ıncıdence of*
glaucoma although such mıght have been antıcıpated (*vıde*
p 18) It ıs to be remembered that hıgh systemıc blood
pressure ıs often assocıated *wıth low capıllary pressure*

Sınce both eyes usually have a sımılar structure, glaucoma
ıs lıkely to be bılateral, but one eye ıs generally affected before
the other

The anatomıcal effects of pathologıcal ıncreased ıntraocular
pressure are as follows The already shallow anterıor chamber
ıs made stıll more shallow In an early acute attack the perı
phery of the ırıs ıs merely apposed to the corneo sclera In

the later stages and in chronic glaucoma of some standing it is firmly adherent   The longer the condition has lasted the firmer is the union   The iris is first bound down by organised exudate, later, the iris stroma atrophies and the inner wall of Schlemm's canal, which may be almost obliterated, is covered only by degenerated retinal pigment epithelium   Anterior to this a "false" angle is formed where the iris leaves the cornea , no filtration can take place either through the peripheral anterior synechia or through the false angle

The part of the eye which suffers earliest and most from the increased pressure is the head of the optic nerve   The lamina cribrosa, which is more resistant than the nerve tissue is less resistant than the sclerotic   Hence it becomes pushed backwards the nerve fibres being depressed also   The first mani festation of the effects of pressure is a bowing backwards of the connective tissue which forms the lamina cribrosa, so that it becomes concave anteriorly instead of passing straight across the porus opticus   This effect continually increases, until the lamina cribrosa is displaced backwards as a whole   Meanwhile

the nerve fibres have been pressed together, so that the papilla becomes flat or depressed   The pressure causes the nerve fibres to atrophy, so that finally the lamina cribrosa is exposed upon the surface

Fig 163 —A diagram of meridional section of normal disc   B, d agram of meridional section of glaucomatous cupped disc   Note the d s placement backwards of the lamina cribrosa.

In the final stage a deep cup is formed, generally having overhanging edges

The steady or recurrent often only moderately raised pres sure of chronic glaucoma is more liable to cause cupping of the disc than the rapidly induced high pressure of acute glaucoma   Hence the disc may appear normal after the relief of acute glaucoma by operation   It must be remembered, however, that the acute attack may be superposed upon a long standing chronic glaucoma

Pulsation of the arteries at the edge of the disc is often seen in glaucoma   While venous pulsation is of little importance, spontaneous arterial pulsation is always pathological (*vide* p 127)   It is not always spontaneous in glaucoma if the tension is not very high, but even then it is induced by very slight

pressure of the finger through the lid   The arterial pulsation is due to the increased pressure upon the walls of the vessels so that the intravascular pressure is only able to force blood through at the height of the cardiac systole

Other parts of the eye show less change   The pressure causes degeneration of the nerve fibre layer of the retina The choroid becomes degenerated and thinned, only the larger *vessels remaining*   The *ciliary body becomes degenerated in the last stages* after which the tension may cease to be raised owing to defective secretion of lymph

The *subjective effects of pathological increased intraocular pressure are manifold*   Pain is complained of, due to stretching of the sensory nerves of the eye   The patient sees coloured haloes round lights, these are due to alteration in the refractive conditions of the corneal lamellæ The colours are generally distributed as in the spectrum with red at the outer margin in the ring The pupil becomes slightly dilated and immobile owing *probably to œdema and pressure on the ciliary nerves* as they run through the choroid   Rapid diminution in the amplitude of accommodation may be a prominent feature   so that there is an apparent increase in presbyopia   It is attributable to pressure on the ciliary nerves and on the ciliary muscle Diminution of vision is due to cloudiness of the media and retardation of the blood flow and pressure on the nerve fibres in the retina and optic papilla   Cloudiness of the media affects the cornea principally, and is due in the early stages to altered refractive conditions in the later to œdema   Pressure on the nerve fibres first affects the *temporal* side of the retina and therefore the nasal side of the field   Later the field becomes contracted in all direc-

Fig 164 —Horizontal meridional section of a glaucomatous eye

tions, and central vision is depressed   Finally, vision is
abolished, owing to total atrophy of all the fibres

Acute Glaucoma   In even the most acute cases of glaucoma
careful inquiry will often elicit prodromal symptoms
Transient attacks of obscuration of vision, as if a cloud
were in front of the eye, have occurred   Bright lights have
appeared to be surrounded by rainbow haloes   A feeling of
discomfort in the eye and neuralgic headache accompany
these symptoms   Such attacks become more frequent, come
on especially at night and after excitement or worry.   It is
noticed that stronger glasses are required for near work.
This condition may extend over months or years

If the patient is examined while the symptoms are present
it will be found that there is a slight haziness of the cornea, so
that it looks bluish, like glass that has been breathed upon—
hence the term glaucoma (γλαυκος, sea green)   If the field of
vision is taken between the attacks some slight contraction of
the nasal field may be found, but central vision may be perfect.

The acute attack sets in suddenly   It may be due to some
condition inducing venous congestion, *e g* constipation, men
struation, over feeding, alcohol, &c , or to worry, fatigue, a
recent illness, or to the instillation of a mydriatic   The pain
and anxiety of acute glaucoma in one eye may induce an attack
in the other   Intense pain is felt in the eye and over the dis
tribution of the fifth nerve   The pain is frequently so bad that
it causes vomiting, and the attack is liable to be mistaken for
a severe "bilious attack"   The temperature may be raised.
The constitutional disturbance is often so great that the patient
is prostrated, the pulse becoming irregular and intermittent
The vision rapidly diminishes, so that in a few hours only hand
movements can be recognised   In a considerable number of
cases both eyes are affected almost simultaneously

Objective examination shows some œdema of the lids and
conjunctiva ; the latter is intensely congested and looks dusky
red, owing to the dilatation of the veins   Ciliary congestion
is marked   The cornea is cloudy and insensitive to the touch
The anterior chamber is very shallow   The iris is discoloured,
the pupil moderately dilated and oval, generally with the long
axis vertical   The reactions to light and accommodation are
abolished   Ophthalmoscopic examination is impossible owing
to the cloudiness of the cornea   The tension of the eye is
considerably raised

There is no true inflammation in the early stages, so that
the term inflammatory glaucoma, frequently used, is mad

visable, it should be replaced by *congestive glaucoma* The condition is probably in part due to the liberation of histamine in the tissues, as indicated by excess of histamine in the vitreous in glaucoma associated with epidemic dropsy in India (Kirwan) This would account for the failure of adrenaline and its compounds (glaucosan lævo glaucosan) to relieve the congestion (*vide* p 17), it would also account for the failure of choline derivatives, *e g*, doryl, and histamine in the form of amino-glaucosan (*vide* p 64)

If the condition is not relieved by operation, the amount of permanent diminution of vision depends upon the severity and duration of the acute attack   Total abolition of vision may result   More frequently improvement occurs, ushered in by diminution of pain   Considerable lowering of the visual acuity, and still more contraction of the field, follows every acute attack   All grades, indeed, may be met with, from the mild prodromal attacks to the severest, with complete blindness The tension remains permanently slightly elevated   Some congestion and irritability persist   The pupil reacts sluggishly, and the iris shows signs of atrophy, usually first in one or more sectors   Ophthalmoscopic examination now becomes possible Cupping of the optic disc may or may not be found, according to the duration of the raised tension before and after the acute attack   A single acute attack is not followed by cupping immediately, for this demands more or less prolonged high tension

In every disease of one eye the other should be thoroughly examined   In acute glaucoma it may be found that chronic glaucoma has existed long unobserved in the other eye, and well marked cupping of the disc may be present   The same causes which induced the acute attack in one eye may rapidly induce a similar attack in the other   The pain and worry associated with preparations for operation and so on increase the danger   This eye should therefore be carefully watched and prophylactic measures adopted   It is usually sufficient to instil a drop of 0 5 per cent solution of eserine in the sound eye every day so as to keep the pupil contracted

It is of the utmost importance that pathological cupping of the disc should always be recognised when present (Plate VIII, Fig 2)   When fully developed it differs in ophthalmoscopic appearance from a deep physiological cup, with which it is most likely to be confounded in that the excavation reaches to the edges of the disc and the sides are steep, not shelving The retinal vessels have the appearance of being broken off at the margin of the disc   If they are accurately focussed there

their continuations upon the floor of the cup are slightly out of focus and look broader and paler. When the edges overhang, as is often the case, the course of the vessels as they climb the sides of the cup is hidden. By the indirect method slight lateral movement of the large lens causes a distinct parallax (vide p 117) which is more marked the deeper the cup. By the direct method the difference in level between the vessels at the edge and on the floor can be measured (vide p 121)

There is always some atrophy of the optic nerve when the disc is cupped by the glaucomatous process, it is therefore not surprising that there may be great difficulty in distinguishing a shallow glaucoma cup from the slight depression which follows simple atrophy of the nerve without increase of tension (vide p 397) If the cup is deep and total it is certain to be glaucomatous, except in the rare cases of ectatic coloboma of the disc (q v) In shallow glaucomatous cups the disc has a pink colour, whereas the atrophic cup is white In many early cases all the conditions have to be weighed care fully before it is possible to come to a definite conclusion, the field of vision usually affords the most important criterion, the contraction being chiefly nasal in early glaucoma, concentric in optic atrophy

The final stage of the untreated disease is *absolute glaucoma.* The eye is completely blind. The anterior ciliary veins are dilated, and a reddish blue zone surrounds the cornea The cornea is clear, but insensitive, it may have vesicles (bullous keratitis) (Fig 149) or filaments (filamentary keratitis) upon it The anterior chamber is very shallow The iris is dilated, atrophic and may have a broad zone of pigment around the pupil (ectropion of the uveal pigment) The pupil is grey or greenish, instead of jet black The optic disc is deeply cupped The tension is high, usually the eyeball is as hard as stone Such an eye is generally painful with temporary exacerbations, though patients often prefer to bear the pain rather than submit to excision If it is still retained degenerative changes occur The more important are due to giving way of the sclerotic before the continued high intraocular pressure In this manner scleral staphylomata are produced They may be in the neighbour

FIG 165 --Diagram showing intercalary region

hood of the ciliary body—ciliary staphylomata, or at the equator—equatorial staphylomata

Anatomical investigation shows that *ciliary staphylomata* are of two kinds In one, the region where the iris is adherent to the corneo sclera gives way (Fig 165) These are called *intercalary staphylomata* (Fig 166) In them the iris projects into the anterior chamber from an attachment at the anterior margin of the staphyloma, while the ciliary body, little altered, forms the posterior margin The other form is the true *ciliary staphyloma* (Fig 167) In this the region of the

ciliary body itself gives way, so that it becomes spread out over the *inner surface of the ectasia* In many cases both parts become ectatic Clinically it is impossible to distinguish between these forms

Equatorial staphylomata can only be seen clinically when the eye is turned well to one side and the lids separated The thinning and bulging of the sclerotic occurs principally

Fig 166 —Diagram showing intercalary staphyloma

at the spots which are weakened by the perforation of the vortex veins and are unsupported by the recti muscles Such globes may become enormous, with walls as thin as paper There is considerable danger of rupture from slight injury

Sooner or later the tension becomes normal or diminished in eyes with absolute glaucoma This may be due either to stretching of the walls as already explained, or to degeneration of the ciliary body, whereby its secretory functions are diminished or abolished Usually both factors play a part, varying according to the particular case Such an eye may even shrink, but more commonly ulceration of the cornea occurs, owing to the defective resistance of the degenerated tissues Hypopyon

Fig 167 —Diagram showing true ciliary staphyloma

ulcer, panophthalmitis, phthisis bulbi then form the sequence of events

Diagnosis Acute glaucoma is more likely to be mistaken for iritis than any other disease The differential diagnosis has already been discussed (p 260)

Treatment Acute glaucoma demands immediate energetic treatment It is imperative that the tension shall be reduced as soon as possible Theoretically this is best and most permanently effected by immediate operation, as in many cases other measures fail The moment is, however, an unfavourable one for operation The conjunctiva is chemosed, the anterior chamber is extremely shallow, there is no time for exhaustive preparations, and a general anæsthetic will be necessary owing to the impermeability of the stretched cornea to local anæsthesia Owing to the constitutional disturbance and the irregular action of the heart, one may feel diffident about giving a general anæsthetic in these cases The danger is liable to be over estimated

It is permissible to try other remedies for a short time first It is first essential to draw the congested iris away from the filtration angle This is attempted by instilling eserine (1 per cent) into the affected eye at five minutes' intervals for half an hour, and then hourly, until the intraocular pressure is reduced or an operation becomes imperative Eserine ($\frac{1}{2}$ per cent) should be instilled into the other eye and continued twice daily during the critical state of the affected eye The action of eserine is assisted by medical diathermy An eye pad, composed of layers of cotton wool wrung out in warm saline and applied evenly to the closed lids, is attached through a special headband to one of the electrodes, the other being bound to the arm The current is slowly increased until the heat is as strong as the patient can bear This is generally between 300 and 600 milliamperes it is maintained at this reading for five minutes and then slowly reduced to zero An injection of morphia (gr $\frac{1}{4}$) also helps to relieve pain, and acts as a miotic

Rectal administration of 6 ounces of 50 per cent magnesium sulphate is more efficacious in reducing the intraocular pressure than the intravenous injection of hypertonic saline (50 c c of 30 per cent sodium chloride), which is not free from risk, especially in patients with albuminuria

The application of leeches to the temple assists the reduction of congestion Hot bathings are given hourly in the intervals of diathermy, which is not used more than twice a day

Even if the results are satisfactory trephining must be performed when the eye is quiet If it is imperative to operate

in the acute stage, iridectomy should be performed, not
trephining There is, indeed, one objection to palliative
and non operative treatment, even when it is successful
viz , that the patient may refuse the radical operation when
the acute stage has passed off In cases in which this is to
be feared, it is advisable in the patient's interest to perform
the operation at once On the other hand the ultimate result
is more satisfactory if trephining can be done—for one reason
because it causes less astigmatism than iridectomy If then
should be a lacrymal mucocele (*vide* p 651) present both
canaliculi should be ligatured, or the puncta cauterised with
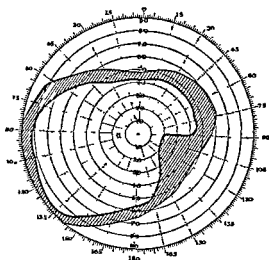
Fig 168 Field of vision in commencing glaucoma showing
contraction of nasal side

the actual cautery If both eyes are affected, both should be
operated upon at the same sitting In no other disease is this
procedure indicated or even justified

If the intraocular pressure remains high in spite of treatment
an immediate operation is necessary The classical operation
is iridectomy (*vide* p 471), and the results have usually been
very good It has the disadvantage of causing some astig
matism, which is avoided by trephining , but owing to the
extreme congestion of the eye the technical difficulties of the
latter operation are increased These, however, have been
much reduced with modern methods of anæsthesia by intra
venous sodium pentothal, which lowers the blood pressure
and incidentally the intraocular pressure also It is possible

to prevent a sudden reduction of the intraocular pressure by withdrawing the trephine very slowly A wide peripheral iridectomy should be done, leaving the sphincter pupillæ intact

Iridectomy was first tried for glaucoma by von Graefe (1856) on the erroneous theory that as it lowered the tension of the normal eye (which is not true) it would be beneficial in glaucoma The true explanation of the efficacy of iridectomy in glaucoma is that it reopens the angle of the anterior chamber and thus restores filtration In acute glaucoma the iris is at first merely apposed to the corneo-sclera at the
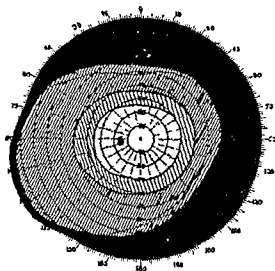
Fig 169 —Normal fields with tests as follows —10/300 6/°000, 3/°000 (*vide* p 141) (A H H Sinclair)

periphery The manipulations draw it away Part of the iris is then torn away at its ciliary attachment, and the angle of the anterior chamber is reopened in this situation There is some reason to think that fluid is absorbed by the cut edges of the coloboma, for wounds of the iris do not heal by cica-trisation, the lymph spaces of the stroma always remaining continuous with the anterior chamber at the cut margins

In absolute glaucoma pain is best relieved by hot bathing and internal administration of aspirin If possible consent should be obtained to excise the eye If this is refused the pain may be relieved for a time, varying in different cases, by a retro ocular injection of 1 5 c c of novocain (4 per cent)

followed seven minutes later by alcohol (80 per cent) A firm pad and bandage is applied for twenty four hours If the pain recurs this treatment can be repeated It is rarely justifiable to trephine or perform any other operation merely for the relief of tension in these eyes, since there is nearly always a risk that the cause of the glaucoma may be an intra ocular malignant growth, usually sarcoma of the choroid

Chronic Glaucoma, sometimes called simple glaucoma, is fundamentally the same disease as acute primary glaucoma every grade of severity is met with but the more chronic
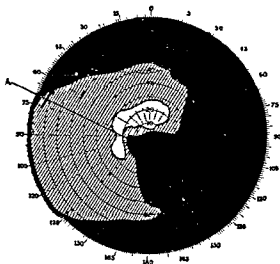
Fig 170 —Glaucoma fields with 3/250 and 1/⁰⁰⁰⁰   A = Position of blind spot (A H. H Sinclair)

forms are so insidious that special attention must be directed towards their discovery

The patient usually complains of transient attacks of obscuration of sight, and of gradually diminishing acuity of vision , but in some cases there may be no history of haloes and the diminution of vision is continuous and very insidious

The eyes may appear perfectly normal at the first examina tion, though sometimes the anterior ciliary veins are congested, and the pupil is somewhat dilated and sluggish An abnormally small cornea should draw attention to the possibility of glaucoma, and hypermetropia increases the probability The tension may be quite normal, and is found to be elevated only during an attack of cloudy vision Hence it may be necessary

to examine the patient frequently and at various times in the day, especially during such attacks

Subjective examination will often reveal no diminution of central vision   Hence it is of the utmost importance to take a careful chart of the field of vision   The commonest change is partial loss of the nasal field, often accompanied by some general contraction (Fig 168)   The change in the nasal field may be regular in outline, or there may be indentations with the apex directed towards the fixation spot   Such sectoral defects may be above or below   In later stages the general contraction is more marked, and eventually only a paracentral patch of the temporal field persists, central vision being abolished   Partial scotomata are to be found by special means before nasal con striction occurs, or when it is only slightly developed   If the central area of the field is mapped out on a Bjerrum's screen (*vide* p 143), or with a suitable scotometer, an area of relative defect can frequently be traced in direct continuity with the blind spot (*Bjerrum's scotoma*)   The scotoma may pass in an arc from the blind spot above or below the fixation point, or may form a complete annular scotoma   It is due to injury of bundles of nerve fibres at or near the edge of the disc   The destruction of these fibres is also said to account for a charac teristic sharply defined horizontal edge to the lost portion of the field on the nasal side (*Ronne's step*) (Figs 168, 170)   The earliest sign of all is said to be a sickle shaped extension of the blind spot above or below, or both, with the concavity of the sickle directed towards the fixation point (*Seidel's sign*) , this is of more doubtful significance   Paracentral scotoma may persist with a full peripheral field for months or even years, but eventually the characteristic constriction of the nasal field sets in, and then often progresses rapidly   A relative central scotoma sometimes follows rapidly on the development of the paracentral scotoma   the prognosis is worse in these cases

Defective light sense is probably always an early feature of chronic glaucoma   The light-minimum is raised and dark adaptation is slowed, so that patients take longer to get used to the lower degree of illumination in passing into a dimly lighted room, a disability which becomes increasingly dis turbing in the later stages

Ophthalmoscopic examination will often show some cupping of the disc , frequently it is far advanced, though the symptoms have been so slight as to have passed almost unnoticed   The field in nearly all these cases will be found to be much damaged

Primary glaucoma invariably attacks both eyes sooner or later, usually one is considerably more advanced than the other The chronic form sometimes occurs in young people
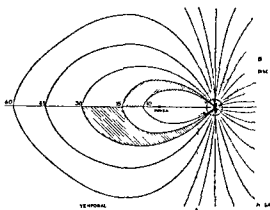
Fig 171 —The course of the nerve fibres in the retina showing fibres involved by lesions at A and B
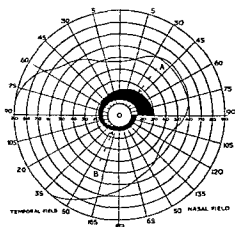
Fig 172 —Scotomata in field of vision corresponding to lesions A and B

and seems to attack men almost as frequently as women It also occasionally occurs in myopic eyes
There is no evidence that chronic glaucoma is due to increased blood pressure though so frequently occurring in

elderly patients, it is often associated with it Although the
intraocular pressure responds passively to rapid changes in
the general blood pressure (*vide* p 19), slow changes are com
pensated and a fresh equilibrium of secretion and excretion
is established

Diagnosis Chronic glaucoma has frequently been mistaken
for cataract or optic atrophy Cases occur in which the gradual
loss of vision is attributed to cataract, and the patient is told
that nothing can be done until the cataract is ripe for opera
tion Vision is thus irretrievably lost As a rule diagnosis is
very easy The haze of the pupil is bluish, diffuse and uniform
unlike the usual appearance in cataract The pupil may be
slightly dilated and generally reacts less to the stimulation of
light Examination with the ophthalmoscopic mirror in most
cases renders the diagnosis certain by showing a uniform red
reflex and the absence of opacities in the lens

Doubt as to the presence of glaucoma may arise in cases
with senile striæ in the lens In patients predisposed to
glaucoma the swelling of the lens which occurs in the early
stages of cataract (*vide infra*) may lead to increase of the intra
ocular tension The disc is not usually cupped in these cases
but there is generally more failure of vision than is accounted
for by the lenticular opacity, and the field of vision may show
contraction on the nasal side , the reaction of the pupil to
light may be sluggish In such cases it is advisable to do a
preliminary iridectomy, which should be of the glaucoma type
with a large and peripheral coloboma

Cupping of the disc in glaucoma is accompanied by atrophy
of the nerve fibres, and it may be difficult to distinguish this
atrophy from optic atrophy due to other causes especially
those giving rise to what is known as " primary " optic atrophy
The latter condition shows some depression of the surface of
the disc which is usually too slight to be actually measured by
the ophthalmoscope, but is demonstrated by the bending of
the vessels as they pass over the edge of the disc The depres
sion is greater in most cases of chronic glaucoma In cases
which give rise to difficulty in diagnosis little aid is afforded
by the tension of the eye, which may be normal or inappreciably
raised at the time of examination Reliance must be placed
upon the history of the case, the condition of the cornea and
anterior chamber, and the record of the field of vision The latter
shows concentric constriction in primary optic atrophy, more
marked contraction of the nasal side in glaucoma Accurate
mapping out of the blind spot and the central region of the

field on a large scale reveals changes in glaucoma (*vide supra*) which do not occur in optic atrophy /

Treatment As soon as the diagnosis is made miotics pilocarpine (½ per cent) or eserine (¼ to ½ per cent) twice a day, should be instilled The eyes may be kept under observation for a time unless the disease is far advanced If miotics fail to control the intraocular pressure or if the loss of the visual field continues to progress operation must be under taken *Miotics never cure chronic glaucoma* Hence they must be adopted only as a temporary means of alleviation or as useful adjuncts *They cause some conjunctival and ciliary congestion if used constantly* Pilocarpine is the less irritating but perhaps less efficient If these fail "doryl," a choline derivative, may be used in 0 75 per cent solution Gentle massage with the finger tips is certainly useful promoting lymph flow, and temporarily reducing tension

Until a few years ago iridectomy was the operation invariably performed for the relief of chronic glaucoma The prognosis of iridectomy however, is not nearly so good as in the acute form owing to the fact that the periphery of the iris is often firmly adherent to the corneo sclera before the condition is diagnosed Hence a special endeavour was made to open up the occluded angle If the section is made at the apparent corneo-scleral margin when the iris is torn away it is almost certain to tear at the false angle and little or no good results It was customary, therefore to make the section as peripheral as is consistent with safety to the ciliary body, i e 2 mm behind the corneo scleral margin, with the object of carrying the incision through the adherent parts of the iris It must be confessed that this object was seldom if ever attained

It was found however, that this method of performing iridectomy sometimes succeeded in spite of the impossibility of restoring the normal method of filtration It effected this by establishing a *filtering scar* The new scar in these cases is composed of spongy tissue, through the interstices of which the intraocular fluid is able to make its way into the subconjunctival tissue, where it is absorbed

Deliberate attempts have therefore been made to establish a safe filtering scar for the relief of chronic glaucoma Such a scar is usually formed only if there is some impediment to proper cicatrisation as for example when the iris is incarcerated in the wound (*iridenclesis*) There is some danger in leaving a knuckle of iris in the wound when doing an iridectomy, since such a procedure involves grave risks of iridocyclitis

secondary infection of the eye, and sympathetic ophthalmia Good results, however, have been obtained by Holth's method

In an ordinary corneo scleral section the lips of the wound are in good apposition and sound healing rapidly takes place This is much less likely to occur if there is a gap between the lips of the wound Under these conditions the gap becomes filled with loose scar tissue and a filtering cicatrix may result Various operations have been based upon this principle In *Lagrange's operation* an ordinary iridectomy is performed, but before closing the wound a small piece of the anterior lip is snipped off without wounding the conjunctival flap In *Herbert's operation* a small rectangular trap door is cut in the sclerotic just outside the limbus, the hinge being towards the cornea A circular wound in the sclerotic offers the best chance of success theoretically

Trephining is the operation which is now generally performed for chronic glaucoma (*vide* p 478) By it a disc 1 5 mm in diameter is removed from the wall of the globe just inside the limbus, so that part lies in the cornea and part in the sclerotic. The knuckle of iris which prolapses into the wound should be excised, so that a small peripheral iridectomy is performed If a larger disc is removed there is danger of the tension becoming permanently too low, with the risk of malnutrition of the eye The operation sometimes fails from blockage of the wound with iris or too dense scar tissue Filtration may be encouraged by gentle massage of the eyeball through the upper lid Secondary infection of the eye is liable to occur from injury of the epithelium covering the bulging conjunctiva but it is rare and is a risk which may be taken justifiably in treating so grave a disease as glaucoma If trephining fails it can be repeated at some other part of the limbus, but the wound should always, if possible, be placed where it is covered and supported by the lid, though it should not be too close to the previous site

Trephining is uncertain in its results and is liable to be complicated with serious dangers, both immediate and remote, yet in my opinion it affords the best means on the whole yet devised for dealing with chronic glaucoma It seldom causes any improvement in vision or in the field of vision, but it usually prevents further loss

In very advanced cases the field of vision may be found reduced almost to the fixation point Experience teaches that in these cases operation may not only do no good, but may

result in the sudden complete loss of all vision After explain
ing this risk to the patient it is still advisable in most cases to
perform the operation because this unfortunate result is rare
and in any case the eye will become blind and probably painful
unless the tension is relieved

Since glaucoma always occurs in the other eye sooner or
later the question of a prophylactic operation in this eye arises
Since it is attended by some danger, both immediate and
remote, and since the advent of
glaucoma may be long delayed it is
inadmissible to operate until some
slight contraction of the nasal field
can be demonstrated The greatest
care must be taken to warn the
patient of the danger of the disease
attacking the other eye and of the
earliest symptoms He should be
examined thoroughly and the field of
vision taken every three months, and
he should be instructed to consult
the surgeon at once if any signs of
the disease occur Weak pilocarpine
or eserine drops may be used every
other day as a prophylactic measure
and the general regime should be
ordered so as to avoid cerebral con
gestion He should also be warned
against putting drops lotions or
ointment of any kind into his eyes
without the advice of an ophthalmic
surgeon

Fig 1 3 —Diagram of eye
with infantile glaucoma
(buphthalmia) Note the
stretching of the corneo
sclera at the periphery the
flattening and displacement
backwards of the lens the
cupping of the disc and
the general enlargement of
the globe

When one eye has been almost or quite lost at the time of
the first visit it becomes a serious question whether the better
eye should not be operated upon rather than the worse Many
such difficulties arise in the treatment of glaucoma, and
can only be decided by the conditions of the individual
case

Chronic glaucoma may arise in an eye with incipient
cataract Although trephining introduces a serious com
plication to subsequent extraction of the lens (*vide* p 315) it
should be performed in the usual way and in the usual situation
When the extraction is done later the upper part of the section
should be in the cornea slightly anterior to the trephine
hole

Cyclodialysis may be used to reduce the intraocular pressure in chronic glaucoma It has been most successful in aphakic eyes, it should not be used in congestive cases By it a channel is opened up between the anterior chamber and the supra choroidal space An incision about 3 mm long is made in the sclera 4 mm behind and concentric with the corneo-scleral junc tion in the lower temporal quadrant A spatula specially curved to fit the inner aspect of the sclera is inserted and passed forwards between the scleral spur and the ciliary body into the filtration angle Here it is swept transversely through a small arc, breaking down the ligamentum pectinatum and adhesions between the root of the iris and the cornea A conjunctival flap is sutured over the wound

Infantile Glaucoma (*Syns* —*Buphthalmia, Hydrophthalmia*) Glaucoma in rare cases attacks children when it assumes a quite different clinical appearance It arises from congenital blockage of the angle of the anterior chamber, due either to a congenital defect whereby the root of the iris does not become normally separated from the corneo sclera or becomes adherent to it through intra uterine or infantile inflammation In many cases examined microscopically Schlemm's canal has been found defective or absent The fundamental condition is therefore the same as in glaucoma in adults viz, defective filtration of lymph from the eye The reason why it assumes so different a clinical picture is dependent upon the greater plas ticity and extensibility of the walls of the young eye Instead of offering an insuperable resistance to increased internal pressure the sclerotic gives way more or less uniformly, so that the globe becomes very large

The thinned sclerotic of the ciliary region is bluish in colour, owing to the uveal pigment showing through The junction of the cornea and sclerotic also stretches, so that the cornea is forced forwards and assumes a globular shape (keratoglobus) The anterior chamber is therefore extremely deep (Fig 173) There are often slight opacities in the cornea some appearing as lines with double contour, these are due to ruptures in Descemet's membrane The lens does not participate in the general enlargement, owing to the expansion of the ciliary region the suspensory ligament is stretched so that the lens is flattened and displaced slightly backwards This removes some support to the iris, which becomes tremulous (iridodonesis) The optic disc is deeply cupped if the condition has lasted long

The intraocular tension is raised, but often scarcely appre ciably as determined by clinical methods, owing to the expan

sion of the globe. This fact long prevented the true pathology
of the disease from being recognised.

As a result of the expansion the eyes are usually myopic,
though much less than might be anticipated from their length.
This is due to the flattening of the lens and its displacement
backwards, as well as to some flattening of the cornea, all of
which factors tend to counteract the axial myopia. There is
usually astigmatism against the rule, owing to pressure by
the lids on the plastic globe.

Both eyes are generally affected, and buphthalmia occurs
in boys more often than in girls. Equilibrium may be estab-
lished with no further loss of vision, but in other cases rapid
deterioration occurs after puberty, perhaps due to increased
rigidity of the walls.

Buphthalmia occurs frequently associated with neurofibro-
matosis (*vide* p 615), and also with capillary nævus of the
face and angiomatous conditions of the choroid and brain
(*vide* p. 373).

Buphthalmia is to be distinguished from keratoglobus ($q\ v$)

Treatment is unsatisfactory. The best results have been
obtained from anterior sclerectomy with the trephine. Miotics
are useless.

CHAPTER XV

The Lens

THE lens is composed entirely of epithelium, which is surrounded by a cuticular envelope or capsule (*vide* p 9)

It is therefore subject only to metabolic changes, and is incapable of becoming inflamed   Degenerative changes in the lens invariably result in loss of transparency in the parts affected   This condition of partial or complete opacification is called *cataract*

The most important chemical constituents of the lens are the salts and proteins   Spectroscopic examination reveals many metals, of which the most important are sodium, potassium and calcium   The potassium content diminishes with age, but the calcium is relatively constant (Adams), except that it is definitely excessive in cataractous lenses   The proteins consist of euglobulin, and α, β, and γ-crystallins β crystallin is soluble in water and decreases with age a factor in the sclerosis of the nucleus   The crystallins are rich in tyrosine, cystine, and leucine, amino acids which tend to form melanins on exposure to ultra violet light, thus accounting for the normal and pathological (*vide* p 305) pigmentation of the lens   Owing to the absence of a blood supply the lens is dependent for its metabolism on an autoxidation system   This is a reversible oxidation reduction reaction carried out by glutathione (Adams), a cystine like substance containing an SH group, which on oxidation changes into an SS group   The lens also contains a relatively large amount of vitamin C, which also probably acts with glutathione as a reducing agent, the reversible reaction being

Sugar $+$ oxidized glutathione $\longleftrightarrow$ ascorbic acid $+$ reduced glutathione

$$C_6H_{12}O_6 + G\ SS\ G \longleftrightarrow C_6H_8O_6 + 2G\ SH$$
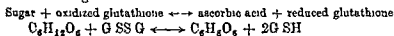
Thermostable forms of crystallin (β crystallin) in the lens effect reduction of the product ($SH \rightleftharpoons SS$)   The mature cataractous lens contains no glutathione or vitamin C

The earliest stage in the development of cataract is an accumulation of fluid either as droplets beneath the capsule or in spindle-shaped spaces between the lens fibres   Clinically this stage can be recognised by inequality as in the refractive indices of the fibres and fluid which give rise to light and dark

streaks when light is thrown into the eye by the mirror The spots and streaks differ from the definite opacities which follow by the fact that if the mirror is tilted slightly the dark streaks become light and *vice versa* In the next stage coagulation of the proteins occurs, forming globular masses called Morgagnian globules At a later stage the fibres break down into rounded masses which are indistinguishable from Morgagnian globules These masses are definitely opaque

Biochemically the essential factor in cataract is the coagulation of the proteins, and many important factors in this process have been discovered in recent years In general, coagulation of proteins occurs in two stages (*a*) denaturation, probably by hydrolysis, whereby the colloidal system becomes more labile, (*b*) agglutination Any form of radiant energy—heat, luminous ultra violet, radium—can cause coagulation Ultra violet rays alter the permeability of the lens capsule (Duke Elder), diminish the efficiency of the autoxidation system (Adams), and render the proteins more vulnerable to variation in hydrogen ion concentration and salt concentration, *e g*, calcium (Burge) Changes in the capsule cause alteration in osmotic pressure and hence in concentration of electrolytes Deformation of the fibres leads to mechanical strains Further, the lens proteins are organ specific especially α and β-crystallins, but investigations of their serological properties have proved contradictory The relative parts played by these factors in the development of various types of cataract are obscure, and have not yet led to any satisfactory prophylactic or therapeutic results

Apart from the experimental production of cataract in animals by various forms of radiant energy it is easily produced in rabbits by administration of naphthalin and other allied poisons dinitrophenol, for example, used for slimming, has rapidly produced posterior cortical cataract in girls Dinitrophenol causes a large increase in tissue oxidation Naphthalene in rabbits is conjugated with cystine and is excreted as 1-α naphthyl mercapturic acid (Bourne and Young), hence the cataract may be due to depletion of the store of cystine in the lens The occurrence of cataract in tetany due to parathyroid deficiency (*vide* p 327) when correlated with the excess of calcium in cataractous lenses suggests a definite association with the rôle of calcium in metabolism Cataract also occurs in the human subject associated with myotonia atrophica and ergotism

Owing to our ignorance of the pathogenesis of cataract treatment apart from steps for minimising the disability, is wholly operative The type of operation depends largely upon the amount of central sclerosis, i e, upon the size of the

nucleus (*vide* p 9) Up about to thirty years of age the nuclear fibres are still fairly soft, and capable of becoming absorbed if the aqueous gains access to them After this age absorption is very slow and incomplete, and if cataract occurs the nucleus must be removed from the eye The size of the nucleus then determines the size of the incision which is necessary The cases in which the nucleus is very small are called *soft cataracts*, since they consist chiefly of soft cortical matter In most patients over fifty the nucleus is large, and these cataracts are called *hard cataracts*, although the lens is by no means hard throughout This only occurs in black cataract, in which the nucleus reaches its maximum size, viz , that of the whole lens Such cataracts require a very large section for their removal In mature cataracts the brownish appearance of the nucleus by oblique illumination gives some idea of its size and an indication of the size of the section necessary for its removal

Cataracts are classified according to the position and extent of the opacity or opacities in the lens and it is found that the situation and distribution correspond with various combinations of clinical conditions—age, general disease, &c In some cataracts the opacities spread and fuse until the whole lens becomes opaque , such are called *progressive cataracts*   in others they remain stationary Senile cataract which is the commonest form of all, is a progressive cataract

Senile Cataract This as its name implies rarely occurs in persons under fifty years of age

In *incipient* senile cataract radial spokes or sectors of opacity are seen with clear areas between them (Figs 174, 175) They are difficult to see in daylight or by oblique illumination

1   2   3

FIG 174—Senile cataract   1 section showing opacities in the cortex
2 appearance by reflected light—dark striæ on a red background
3 appearance by oblique illumination—grey striæ on a dark background (Nettleship)

(*vide* p 95) and cataract should not be diagnosed without confirmation with the ophthalmoscope With the undilated pupil only the ends of the spokes are seen but when the pupil is dilated with cocaine or homatropine (*never* with atro

pine, *vide* p 284), the linear opacities are often found to be
the apices of sectors, with their bases towards the periphery
They generally begin in the lower part of the lens, especially
the lower nasal quadrant   Careful examination with oblique
illumination and the ophthalmoscope will show that the
opacities are in the superficial parts or cortex of the lens, some
in front of the nucleus, others behind   They start from the
region of the equator and extend towards the axis of the eye,
more and more spokes and sectors developing as time goes on

Seen by oblique illumination the opacities are grey (*vide*
p 95), seen with the ophthalmoscope mirror at reading
distance they appear black against a red background   At
the very earliest stage the opacities shift with the incidence

Fig 175—Commencing
senile cataract the
striæ confined to the
lower part of the lens
a very common mode
of commencement

of the light, showing that they are
merely differences of refractive index
(*vide* p 303)   Lens striæ are usually
preceded by sectorial alterations in the
refractive indices of the lens fibres
These are best seen with the plane
mirror, looking alternately light or dark
as the incidence of the light is changed
They account for the uniocular polyopia
which the patients often notice

The pupil in old people is seldom so
black as in the young and is sometimes
distinctly grey   If the greyness is uni
form, cataract should not be diagnosed
unless definite opacity is shown on ex
amination with the ophthalmoscope   This greyness without
opacity is caused by increase in the refractive index of the
cortex of the lens in old people (*vide* p 53) and is due to
increase of reflection and scattering of light

The above description applies to the commonest arrange-
ment of the opacities in senile cataract, it may be dis
tinguished as the *subcapsular* type   Two other types occur
less frequently   In one group the opacities are *supranuclear*
They are more variable in appearance and consist of con
centric lines radial streaks and cloudy patches   This irregu
larity distinguishes them from lamellar cataract (qv)   In
the third group the opacities are *intranuclear*, by which term
these cases may be distinguished from the congenital nuclear
cataract   In this group the nucleus of the lens is diffusely
cloudy, gradually clearing towards the peripheral cortex
Combinations of the various types are not uncommon sub

capsular sectors being associated with intranuclear cloudiness or the latter with supranuclear opacities   Moreover dots of opacity occur   They are larger and denser than the dots of congenital punctate cataract, and are unlike that form in being slowly progressive   Punctate senile cataract may appear as early as twenty to thirty years of age   The intra nuclear form is also earlier than the ordinary subcapsular, occurring at about forty years of age
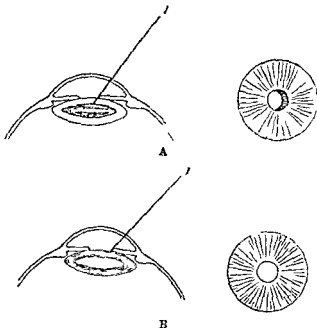
Fig 176 —A, shadow of iris by oblique illumination in immature cataract ; B absence of shadow in mature cataract

In the progressive stage of senile cataract the lens contains more water than normal, and this is associated with swelling of the fibres   When the opacity has become considerable the swelling causes an appreciable *intumescence* of the whole lens shown by the increasing shallowness of the anterior chamber This may be the cause of increased intraocular pressure in eyes predisposed to glaucoma (*vide* p 284)

The nucleus in the common subcapsular type undergoes little change and does not become opaque, but eventually the whole of the cortex is cataractous   The cataract is then said to be ripe or *mature*   The whole of the pupillary area may

appear to be opaque before the cataract is mature, since the most superficial layers of the cortex are the last to degenerate As long as there is any clear lens substance between the pupillary margin of the iris and the opacity the iris throws a shadow upon the grey opacity when light is cast upon the eye from one side (Fig 176, A) When the cortex is completely opaque the pupillary margin lies almost in contact with the opacity, separated only by the capsule, the iris then throws no shadow, and the cataract is known to be mature

(Fig 176, B)   This is an important guide to the most favourable time for operation by the extracapsular method

At this stage it will be found that the anterior chamber has regained its normal depth   The watery fluid has been absorbed from the lens, which has again returned to its normal volume

If the process is allowed to go on uninterrupted the stage of *hypermaturity* sets in.   The cortex is then completely disintegrated and transformed into a pultaceous mass   Usually the loss of water continues so that the lens becomes more and more inspissated and shrunken The lens is then flat and yellow, often with cretaceous deposits and bright specks due to crystals of cholesterin   The anterior capsule becomes thickened by proliferation of the anterior cubical cells, so that a dense white capsular cataract is formed at the anterior pole in the pupillary area   Owing to shrinkage the lens and iris become tremulous, the anterior chamber being much deepened   Degeneration of the suspensory ligament may lead to luxation of the lens

Fig 177 —Diagram of Morgagnian cataract N nucleus of lens

Sometimes the absorption of water ceases at the stage of maturity   The cortex then becomes quite fluid, and the nucleus sinks to the bottom of the thickened capsule   The liquefied cortex is milky, the nucleus appearing as a brown shading limited above by a semicircular line   The nucleus alters its position with changes in position of the head   Such a cataract is called a *Morgagnian cataract* (Fig 177)

In rare cases the sclerosis of the lens fibres which causes the development of the nucleus extends beyond the usual limits, so that the whole of the lens becomes converted into nucleus Such a lens is hard, dark brown and semi transparent   The

pupil looks black, the brownish colour being revealed only by oblique illumination   The condition is called *black cataract* though strictly speaking it is not a true cataract   Central intranuclear senile cataracts often show a brownish colour by oblique illumination, due to coincident hyper sclerosis (*vide* p 305)   They occur more frequently in myopic eyes

Symptoms   The appearance of black spots in front of the eyes is usually the first symptom complained of   They differ from the ordinary muscæ volitantes occasionally complained of in normal eyes, and much exaggerated in cyclitis, &c, in that they are stationary, retaining their relative position in the field of vision in different positions of the eye   Uniocular polyopia another symptom, is the doubling, trebling, &c, of the objects seen with the eye   It is due to the irregular refrac tion of the degenerating lens, so that several images are formed of each object   It is often worse on looking at bright lights, and is therefore noticed most in the evening

As the opacity extends and becomes denser, the acuity of central vision suffers, especially when there is much central opacity   In the latter cases vision is often better in a dull light, owing to the dilatation of the pupil   In most cases of senile cataract the pupillary region suffers latest, so that a bright light is grateful to the patient, both on account of the better illumination and also because the rays which pass through the irregularly refracting peripheral parts of the lens are cut off by the contracted pupil   but the patients seldom like to face the light

Eventually the central area becomes affected and vision steadily diminishes until only perception of light remains   In many cases of mature senile cataract fingers can still be counted at a few feet, or at least hand movements discerned   In all cases light should be perceived readily and the direction of incidence accurately indicated   The detection of the *projection of light* is of the utmost importance, as it affords important evidence as to the probabilities of a good result from operation   It is tested as follows   The opposite eye is covered securely by the palm of the patient's hand   Light is then reflected from the ophthalmoscopic mirror into the cataractous eye from various directions, the patient looking straight forwards   He is told to point with his other hand in the direction from which the light seems to come   He ought to do this readily and accurately   If he does not, we suspect some disease of the retina, *e g*, patches of retino-choroidal atrophy, &c, and a less favourable prognosis is given   Rela-

tively poor projection is not an absolute contraindication to operation, and each case must be determined on its merits

It will be seen that cases of advanced cataract in which the fundus cannot be satisfactorily explored by the ophthalmoscope at the first visit, and in which projection is relatively bad, offer considerable difficulties in deciding the treatment to be adopted It is therefore of the greatest importance that every case of incipient cataract should be most carefully explored and exhaustive notes of the ophthalmoscopic condition taken so that at a later stage, when the fundus can no longer be observed, its previous condition is already on record Every case of incipient cataract should therefore have the pupil dilated so that a thorough examination of the eye may be recorded Homatropine may be used with impunity in most cases, but a drop of 1 per cent eserine must invariably be instilled before the patient leaves, otherwise there is danger that an attack of glaucoma may be induced by the administration of the mydriatic If the eye is definitely of glaucomatous type, with small cornea, shallow anterior chamber, &c , cocaine should be used instead of homatropine The field of vision should also be taken at this stage

The rate of development of senile cataract varies greatly, sometimes occupying many years, or, indeed, the cataract may never reach maturity The progress is usually more rapid in very old people Very rapid maturation in younger patients usually indicates some complication, e g , cyclitis, diabetes &c The forms with fine radial lines are slower than those with cloudy opacities It is best to examine every case at stated intervals a careful drawing of the opacities being recorded at each visit The length of the intervals must be determined by the individual case

Cataract occurs equally in men and women It is usually bilateral, but develops earlier in one eye than the other *Cases* of hereditary predisposition have been recorded, and in some of these the cataract develops at an earlier age in successive generations (" anticipation," Nettleship)

Pathology The cubical cells lining the anterior capsule of the lens (vide p 9) undergo vacuolation in senile cataract Changes in these cells can be made out clinically by using a strong binocular loupe The cortical opacities are due to the formation of Morgagnian globules and the breaking up of the lens fibres (vide p 304) Cholesterin crystals are not infrequently seen in cataracts

Biochemistry of Cataract The normal lens contains more potassium than sodium, the reverse of the aqueous It contains more potassium and phosphorus less sodium and chloride and the same amount of calcium as serum In cataract the calcium may be eight times the amount of the normal (Adams) and the potassium almost disappears The total protein and β crystallin are diminished α-crystallin is most easily precipitated and is peculiarly sensitive to precipitation by calcium (Tsuji), its coagulation is probably the chief cause of the opacity in cataract Glutathione and vitamin C diminish and finally disappear In senile cataract there is no significant change in blood sugar as compared with the increase in diabetic cataract nor in the calcium content, as compared with the diminution in tetany and para thyroid cataract

Senile cataract has been attributed to changes in the cortex produced by shrinkage of the nucleus but this can be, at most only a subsidiary factor Many other theories have been advanced but in the present knowledge of the biochemistry of the lens they must all be regarded as highly speculative The definite association of cataract with calcium metabolism in tetany and the raised calcium content of the cataractous lens are strikingly significant facts In spite of hitherto discordant results the rôle of autocytotoxins whether of the nature of specific immune bodies or toxins derived from disorder of the general tissue metabolism demands further consideration

Treatment No treatment by drugs &c has hitherto proved to have any significant effect upon the progress of uncomplicated senile cataract Potassium iodide drops calcium iodide ointment, hormone treatment especially with parathyroid gland in association with administration of calcium salts and so on have been enthusiastically advocated but are in my experience useless

Elderly patients frequently have slight peripheral opacities of the same nature as cataract Much mental anxiety is often caused by telling them that they have cataract ' If cross examined the surgeon should tell them that they have slight changes of the same nature as cataract but that these are quite common in elderly patients and do not necessarily indicate that an operation will be inevitable in the future

In *incipient* cataract the condition of the patient may be much ameliorated during the tedious process of maturation A low degree of myopia (1 D to 4 D) may develop during this stage, it is due to relative increase in the index of refraction

of the nucleus of the lens a change in the opposite direction to that which usually occurs (*vide* p 53) Astigmatism may develop or undergo change These errors of refraction should be corrected, but often the astigmatism is irregular and glasses afford little help Considerable loss of vision may be associated with the refractive changes which precede the definite formation of opacities Tinted glasses may be found beneficial, the tint varying with the circumstances of the case Amber tinted glasses are most generally useful In certain circumstances, *e g*, at high altitudes they cause an extra ordinary increase of definition even in normal persons, due to absorption of rays of short wave-length Blue glasses, which allow the chemically active violet rays to pass, are not contraindicated in this case, since the cutting off of the more luminous rays is restful These or smoked glasses are indicated, especially when there is a considerable degree of central opacity, since the pupils are kept slightly dilated For the same reason reading may be much facilitated by isolating only a few lines of the print, the remainder being covered by a black paper mask The effect may be obtained with greater certainty by instilling a very weak mydriatic Atropine, $\frac{1}{16}$ to $\frac{1}{8}$ gr to $\frac{3}{1}$, one drop every morning, may be ordered, if homatropine is found not to raise the tension The slightest predisposition to glaucoma *e g*, high hypermetropia, small cornea, very shallow anterior chamber, &c, contraindicates this treatment and it is wise to observe the tension carefully during the treatment in all cases Sometimes weak atropine causes more blurring, in which case it must be abandoned Central opacities often cause diminution of central vision apparently out of proportion to the amount of opacity observed

There is no reason to restrict the use of the eyes in incipient uncomplicated senile cataract, but the patient may be much assisted by instructions as to the arrangement of illumination and so on If the pupillary area is free brilliant illumination will be found best, if the opacities are largely central, a dull light placed beside and slightly behind the patient's head will give the best result

In *mature cataract* the lens must be extracted Before deciding to operate, attention must be paid to details other than those connected with vision, previously described The pupil should react promptly and normally to light Careful search must be made for precipitates on the back of the cornea ("Lp") for the cataract may be a mature complicated cataract (*vide* p 323) The urine must be tested to eliminate

albuminuria and glycosuria, though these do not necessarily contraindicate operation. The state of the conjunctival sac must be thoroughly examined, and a culture taken. The lacrymal sac is compressed with the finger, so that if there is any regurgitation the secretion from it will be examined. A small cotton-wool swab is rotated in the lower fornix and the secretion thus obtained rubbed over a blood-agar slope. Non-hæmolytic staphylococcus albus and xerosis may be considered innocuous, micrococcus catarrhalis and pneumobacillus doubtful. Staphylococcus aureus, pneumococcus, streptococcus, and such like pyogenic organisms contraindicate operation, which in any case should not be undertaken before forty-eight hours have elapsed lest the very dangerous pneumococcus be overlooked.

If there is the slightest conjunctivitis, and, above all, if there is dacryocystitis, a course of preliminary treatment is necessary. Old people frequently suffer from chronic conjunctivitis induced by senile ectropion, &c. It is best treated by relieving the cause as far as possible, and by the use of astringent lotions. An occasional painting with silver nitrate is the most potent means which we possess of removing infective organisms from the conjunctival sac in these cases, since they are carried away mechanically with the desquamated epithelium, &c. Often the process is long and tedious, and doubt as to the safety of operating still persists. In such cases a further bacteriological examination should be made, and if pathogenic organisms are found, especially virulent pneumococci, operation must still be postponed. In cases of doubt the eye may be tied up with a pad and bandage for one night. The pad is examined the following morning, and if there is any discharge upon it, or if the lids are gummed together with inspissated secretion, further treatment and repeated bacteriological examinations are indicated. Irradiation with ultra-violet light and sulphonamides administered by the mouth (*vide* p. 693) have been found efficacious in recalcitrant cases. It is inadvisable to tie up the eye the night previous to operation, for it is found that this procedure favours the growth of bacteria in the conjunctival sac.

The presence of a mucocele is an absolute contraindication to operation. It must be cured (Chap. XXXII.), or the lacrymal sac must be excised, or the canaliculi must be temporarily obliterated. The last may be effected by tying a ligature round each canaliculus or by cauterising each punctum with the actual cautery. The best treatment is usually excision of the sac.

The teeth, nose and throat, and any other likely focus of sepsis, should be examined, and it is very important that any pyorrhœa, &c, should be eliminated before the cataract operation is undertaken

The treatment of *unilateral* and of *immature cataract* offers some difficulty (cf p 322)   When the cataract is mature in one eye while the other retains good vision little advantage is gained by operating upon the cataract   The difference in refraction between the two eyes after operation will be so great that it will be impossible for the patient to see well if the refraction is corrected, and if uncorrected the large blurred image formed by the eye may be a positive disadvantage though it can be relieved by a contact glass   The sole advantage which is gained is an increase of the field of vision on the affected side   This may be a matter of great importance, as in people who work amid machinery or have to go about where there is much traffic   in these exceptional cases extraction is indicated   There is also the slight advantage that the eye is prepared for the time when vision fails in the less affected eye, but this may be long delayed   These slight advantages do not as a rule justify operation, which, it must be remembered, is attended with some, if usually trivial danger, not only to the eye operated upon, but also to the other eye (*vide* p 459)   On the other hand, the cataract must not be allowed to progress to too advanced a condition of hyper maturity   Operation is then more difficult and more dangerous   The case should be watched, and if signs of thickening of the capsule, calcareous deposits, &c, appear, extraction should be performed even though the vision in the other eye is still good

Cases of immature cataract with loss of useful vision require even more skill in the determination of the best time for operation   The difficulties and dangers of extraction are undoubtedly increased by operating while there is still a large amount of clear soft cortex   It is difficult to remove from the eye, tends to the production of iritis and other complications and leads to the formation of dense secondary cataract (*vide* p 322)   Immaturity, however, is not an absolute bar to operation , extraction under these circumstances may be followed by excellent results, especially if performed by the intracapsular method   It must be remembered 'hat the patients are old, and, if not operated upon are doomed to practical blindness, which in the lower classes entails the loss of all wage earning capacity   Operation will probably be attended by at least the recovery of useful vision, whereby the con

ditions of existence are much ameliorated It is not necessary, therefore, to wait indefinitely for complete maturity if useful vision has already been lost

Some surgeons temporise in these cases, performing a pre liminary iridectomy, on the grounds that the operation accelerates the ripening of the cataract It certainly occurs in rare cases, but is by no means constant Preliminary iridec tomy has the advantage of facilitating the subsequent extrac tion, but has the considerable disadvantage of subjecting the patient to the discomforts and dangers of two operations instead of one It may be employed in complicated cases in which it is desired to test the reaction of the eye to operative interference for it is a less severe operation than extraction, and will afford indications as to the advisability of further procedures It is also to be advocated in cases with much diffuse opacity, often more concentrated in the central part of the posterior cortex, form them the diminution in visual acuity is

Fig 178 —Lamellar cataract 1 ' 3 as in Fig 174 (Nettleship)

very marked, maturation is indefinitely delayed and the compli cations produced by a large amount of sticky cortex are much to be feared The extraction of the cataract should not be per formed until at least four weel s after the preliminary iridectomy

Preliminary iridectomy is indicated most definitely in cases of cataract with increased intraocular tension The tension may be raised owing to the swelling of the lens in the incipient stage, in which case iridectomy usually relieves the pressure Nearly mature cataract may be associated with increased tension It might be thought that an ordinary combined extraction would relieve both conditions, but these cases do not usually progress smoothly It is much better to do a preliminary iridectomy, extraction following after the usual interval

In some cases eyes with incipient cataract have been trephined for chronic glaucoma (*vide* p 300) or cataract has developed subse quent to trephining Theoretically it is obviously objectionable to make a cataract incision through the trephine hole though such cases often do well—possibly because extraction may render an eye less prone to the usual form of chronic glaucoma It has been sug

gested to extract downwards but it is probably wiser to make the upper part of the incision in the cornea in front of the trephine hole.

The correction of the refraction after extraction of cataract is dealt with elsewhere (*see* Aphakia, p 530)

Cataracts of Congenital or Infantile Origin   These are almost always partial and stationary   The commonest forms are lamellar and anterior capsular , less common are the various forms of congenital cataract, mostly of lamellar type, sometimes central or total

Lamellar Cataract (Syns —*Zonular, Perinuclear Cataract*) This usually occurs so early in infancy that it is doubtful if it is not congenital   Al though there is no true nucleus at this early age are conveniently termed the nucleus   The opacity in lamellar cataract is situated in the layers surrounding this central core which itself usually contains punc tate opacities , the super ficial cortex is quite clear (Figs 178—180)   When the pupil is dilated a grey

Fig 179 —Lamellar cataract

discoid opacity is seen, surrounded by a perfectly transparent marginal area   The diameter of the disc varies that of the clear peripheral area varying in versely   With the mirror the disc appears black and sharply defined at the outer edge, diminishing in density towards the centre , the peripheral area shows a normal red reflex   Along the outer edge spokes of opacity, re sembling the handles of a steering wheel, often extend slightly into the clear area (Fig 179)   They are called riders, and are due to spindle shaped opacities between the lens fibres in layers a short distance outside the main opacity   Occasionally two con centric rings of opacity are seen   The cataract is usually stationary until late in life, but cases occur in which total opacity gradually develops   Both eyes are almost always affected, though not always to the same degree

Fig 180 —Lamellar cata ract with very slight opacity V = $\frac{5}{6}$

The opacity is always sufficiently large to fill the area of the undilated pupil The diminution of vision is therefore entirely dependent upon the density The patient is brought for examination on account of defective vision He usually holds objects very close to the eyes and is thought to be "short sighted" Myopia is indeed not uncommon in these cases, but the approximation of objects is usually for the purpose of obtaining larger retinal images (*vide* p 37)

There is no doubt that lamellar cataract is due to a period of mal-nutrition at some stage of late intra uterine or early infantile life

Fig 181 —Hypoplasia of teeth

It has been found that lamellar cataract in young rats offspring of mothers fed immediately after birth of the litter on diet lacking in vitamin A, fat, and phosphorus may become normal if the food is replaced by a normal diet No rachitic changes are found in the bones, whereas older animals on a diet poor in vitamin A get rickets under these conditions, but no lens changes Epithelial structures are most affected Epithelium as a rule covers surfaces, and the oldest cells are cast off, being replaced by young cells derived from the basal layer There are two sites in which the epithelium persists (1) the lens, where, owing to its formation as an invagination of epiblast, the oldest cells are central and cannot be cast off, (2) the enamel of the teeth, where the cells become calcified and thus retained Hence lamellar cataract is almost invariably accompanied by defective enamel in certain of the permanent teeth The hypoplasia differs essentially from the condition of the teeth in congenital syphilis The teeth have an eroded appearance, with transverse lines across them, the incisors and canines being most affected (Fig 181)

The time at which the pathological process took place is indicated by the size of the diameter of the opacity and the particular teeth affected with hypoplasia Only those teeth are affected whose enamel germs are being formed at the time As regards the lens, the youngest fibres are the most superficial (*vide* p 9), so that the diameter of the opacity indicates the size of the lens at the

Fig 182 —Anterior capsular cataract (Nettleship)

time The usual diameter of the opacity and the particular teeth affected both indicate that the malnutrition generally

occurs at about the time of birth or shortly afterwards
Concentric rings of opacity are accounted for by successive
periods of malnutrition

The cause of the malnutrition is probably to be found in
errors of feeding and possibly exanthemata   There is some
reason to think that rickets is a cause, and congenital syphilis
has been indicted, but on insufficient grounds   A history of
convulsions is very common

Treatment depends upon the density and the diameter of
the opacity   In cases with dense opacity and very poor
vision with undilated pupils the treatment depends upon
the diameter of the opacity   If it is small with a wide
area of clear cortex, and if distant vision is much improved
when the pupil is dilated and the refraction corrected so
far as possible, an optical iridectomy may be performed
In some cases, however, the opacity increases, so that
iridectomy should not be done until there is fair certainty
that the condition is stationary   Suitable cases for this
operation are therefore quite uncommon   Usually the opacity
is large, and it is then necessary to remove the lens, which
has the grave disadvantage that it abolishes accommoda
tion   Since the patients are almost always seen when quite
young, the central core of the lens does not yet form a hard
nucleus   Non sclerosed lens fibres become absorbed if the
aqueous gains access to them   Hence lamellar cataract can be
treated by discission or needling, whereby an aperture is made
in the anterior capsule through which the aqueous enters
This is the ordinary treatment of lamellar cataract, but
it should not be employed unless the vision is seriously impaired
or the other methods of treatment are impossible   As all
varieties of density are met with the advisability of needling in
cases with fair vision has to be considered   The decision of
this question depends upon whether vision with corrected
refraction and retained accommodation is to be preferred to
probably improved vision after operation without accommoda
tion   I am of the opinion that vision of 6/12, or even 6/18,
with retained accommodation, is more valuable than a prob
lematic 6/9, or even 6/6 without accommodation but with the
necessity of wearing constantly very strong convex glasses for
distance and still stronger ones for near work   I do not
therefore operate in such cases

It is not advisable to needle lamellar cataracts until the
child is 9 or 10 months old   During the waiting period the
pupils should be kept dilated with 0 5 per cent atropine once

every other day so that the retina may be stimulated by light passing through the clear zone   This procedure diminishes the risk of nystagmus or squint developing

Anterior Capsular Cataract (*Syn —Anterior Polar Cataract*)   This form of cataract is commonly known as anterior polar   It is best to reserve this term for any cataract at or near the anterior pole of the lens   since there are two forms of anterior polar cataract viz   anterior capsular and anterior cortical   Similarly the term posterior polar should be used in the same manner   though there is more ambiguity here   There are two forms of opacity which are known as posterior polar cataract   The posterior cortical cataract is the commonest form of complicated cataract (*vide* at p 323) (Fig 186)   The other posterior polar   cataract   is not strictly a cataract at all   since it is due to persistence of part of the posterior vascular sheath of the lens   and is therefore situated upon the posterior surface of the
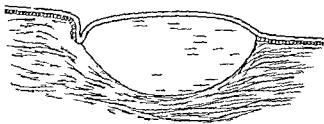
Fig 183.—Diagram of section of anterior capsular cataract

lens   *i e* it is not a true lenticular opacity (Fig 188) though there is always some opacity in the adjacent lens fibres

Anterior capsular cataract is due to abnormal proliferation of the cubical cells which line the anterior capsule (Fig 183) and is usually limited in uncomplicated cases to a small area in the centre of the pupil (Fig 182)   The stimulus to proliferation is caused by contact with the normal or inflamed cornea   Contact of the lens with the normal cornea causes opacity in the lens only if it occurs at an early age   This is indeed fortunate for if it were not so many intraocular operations *e j*, iridectomy would be impossible   In very young children it is probable that a very short time of contact is all that is necessary   The older the patient the longer is the time required   Contact with an inflamed cornea is more liable to produce an anterior capsular cataract than with the normal cornea   In most cases it is due to perforation of a corneal ulcer usually caused by ophthalmia neonatorum   more rarely to a perforating wound

Anterior capsular cataract is sometimes congenital when it is also probably due to contact with the cornea possibly owing to delayed formation of the anterior chamber without actual perforation   In these cases it is almost always bilateral, whereas the acquired form is generally unilateral

When an ulcer perforates the aqueous escapes and the lens and iris are driven forwards into contact with the back of the cornea   If the perforation becomes blocked with iris the anterior chamber re forms   the length of time of contact between the lens and cornea varying in different cases   If it is short   no harm may be done to the lens unless the patient is very young   If it is more prolonged an anterior capsular cataract is formed and the lens adheres more or less to the wound   When the anterior chamber re forms, the lens usually separates completely from the cornea   less frequently the adhesion stretches out into a fine filament which may persist or break   Occasionally the adhesion is so firm that the lens is permanently anchored to the cornea   the eye is usually lost by panophthalmitis or secondary glaucoma in these cases

The dragging upon the adhesion when the anterior chamber is re formed may cause a conical protrusion of the cataract— *pyramidal cataract* (Figs 117, 182)

The deleterious effects of contact may affect the underlying cortical fibres so that an anterior cortical cataract may occur with a capsular one   The cubical anterior capsular cells may grow in between the capsular and cortical opacities   They give rise later to normal transparent lens fibres so that the two opacities become separated by a narrow clear zone of cortex   In the absence of cortical degeneration the opacity is usually so small and sharply defined that vision is little impaired and no treatment is required

Congenital Cataract manifests itself in a variety of different forms   As already stated   *anterior capsular* and typical *lamellar cataracts* may be congenital   Many other forms are nearly allied to the lamellar type   those occurring early in foetal life being small in diameter (*vide* p 316)   To this category belong the following —

Central or nuclear cataract a small spherical opacity in the centre of the lens surrounded by clear cortex

Fusiform cataract also called spindle shaped axial or coralliform an antero posterior spindle shaped opacity, sometimes with offshoots giving an appearance much resembling coral this form shows a great tendency to occur in families

Discoid cataract is also a familial form showing a somewhat

ll defined disc of opacity just behind the nucleus in the posterior cortex

In other congenital cataracts minute points of opacity are seen scattered throughout the lens, or limited to parts—*punctate cataract* Many varieties of this type occur Bluish spots, seen by oblique illumination near the anterior surface of the lens, and of congenital origin, are not uncommon They are almost transparent when viewed with the ophthalmoscope, remain unchanged throughout life and require no treatment A single minute round opaque spot, usually eccentric and situated on the back of the lens, is not infrequently seen in the routine examination of patients with the ophthalmoscope This spot can always be found with the slit lamp, and is caused by the remains of the fœtal posterior vascular sheath of the lens

Most of these congenital cataracts are stationary They may be associated with other congenital stigmata, such as nystagmus (*vide* p 563), congenital colobomata, &c They may require no treatment, or optical iridectomy or discission may be indicated (*vide* p 318) It is wise to wait until puberty in cases apparently suitable for optical iridectomy, the pupils being kept dilated with atropine in the meantime, since some are not stationary but gradually progress to the formation of total cataract

Total cataract may be congenital or the result of progressive partial congenital cataract The lens may be shrunken and much degenerated, and there are often other congenital defects in the fundus, &c These cases should be treated by discission, but the prognosis given must be very guarded Sometimes needling reveals persistence of the posterior vascular sheath of the lens, with or without persistence of the hyaloid artery In such cases violent attempts to remove the opacity by needling will result in the loss of the eye

The pupil is often small with congenital total cataract and reacts very feebly, if at all, to light and on convergence Neither does it dilate appreciably with atropine Attempted discission of the shrunken cataract often causes rupture of suspensory ligament, and it may be necessary to remove the membranous lens with toothed capsule forceps (Fig 150) through a keratome incision Vitreous is usually lost and there may be severe reaction, but the result not infrequently justifies the heroic measures

Congenital cataracts should not in general be needled until the child is 9 or 10 months old If there is a clear peripheral

zone they should be treated like lamellar cataracts (*vide* p 318) In cases where the lens is completely opaque, or the pupil will not dilate and when squint or nystagmus is developing it is advisable to needle at a much earlier age, though there is some risk in doing so

The Treatment of Unilateral Cataract in Children When dense unilateral cataract occurs in a child whether from lamellar or congenital cataract or from traumatism (*vide* ' Traumatic Cataract) so that the pupil becomes grey or white it is advisable to needle early In these cases the appearance of the eye militates against the individual obtaining employment Moreover needling is a less severe operation than extraction of cataract which may become necessary at a later date if the other eye fails The treatment of unilateral cataract in children
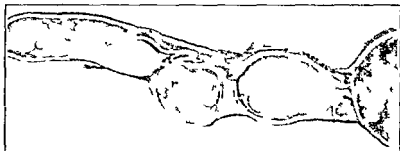
Fig 184 —Secondary cataract from a sect on by Treacher Coll ns

differs therefore from that of a similar condition n adults (*vide* p 314)

Secondary Cataract (*Syn —After cataract*) is the opacity which persists or follows after the extraction or discission of the lens In both these operations the posterior and part of the anterior capsule remain *in situ* If only the posterior capsule remains in the pupillary area the corrected vision will probably be good though it may be much impaired by wrinkling of the capsule and the consequent irregular refraction In many cases especially when the cataract is not quite mature some soft clear cortex sticks to the capsule This becomes partially absorbed by the action of the aqueous but it often becomes shut off from the aqueous by adhesion of the remains of the anterior capsule to the posterior capsule In such cases the cubical cells which line the anterior capsule also persist , they continue to fulfil their function of forming new lens fibres

though those formed under the abnormal conditions are abortive and opaque (Fig. 184). If these remnants lie in the pupillary area a dense membrane is formed through which the rays of light penetrate with difficulty, so that vision is very imperfect. If the previous operation has been followed by iritis, exudates also adhere to the lens remnants and organise, thus contributing a fibrous membrane in addition.

Secondary cataract is demonstrated either by oblique illumination or by the ophthalmoscope If fine, it may be

Fig 185 —Posterior cortical cataract   1, 2, 3, as in Fig 174
(Nettleship)

difficult to see, forming a grey film by the former method, a cobweb-like haze by the latter The denser membranes are easily recognised. They vary in density, showing coarse opaque bands separated by more transparent areas.

Treatment. Secondary cataract requires needling (*vide* p. 481).

Complicated Cataracts (*Syn.—Secondary cataracts*) are those forms which result from malnutrition of the lens, due to disease of other parts of the eye or of the general system. The lens is nourished by lymph which is supplied by the ciliary body. If, owing to disease of the ciliary body or to lymph secreted from abnormal blood, the nutrition of the lens suffers, opacities are formed. They usually commence in the centre of the posterior part of the cortex, and are therefore at first *posterior cortical cataracts* (often called posterior polar) (*vide* p. 319) (Figs. 185, 186). The opacity seldom remains confined to this situation: it progresses, affecting first the periphery of the anterior cortex close to the nucleus, finally involving the whole cortex. In many cases the opacities are fine and dust-like, and are scattered throughout the cortex from the commencement, increasing in number and density as time goes on.

Fig 186 —Posterior cor tical cataract (posterior polar cataract), seen by reflected light.

The total cataract formed in this manner is usually soft and uniform in appearance   In still later stages the watery constituents become absorbed, the capsule becomes thickened, the whole lens shrinks, giving rise to tremulousness of the iris, and other degenerative changes—calcification, &c —ensue

Complicated cataracts occur in advanced cases of cyclitis, in absolute glaucoma, in choroido retinitis—disseminated choroiditis, "retinitis" pigmentosa &c —in high myopia, in detachment of the retina &c , they also occur in suppurative inflammation of the cornea, especially that produced by ulcus serpens   The opacity in the posterior cortex, which is generally stellate in shape, is seen in its most characteristic form in "retinitis" pigmentosa in which disease also its slow progress can be easily watched   The vision is already much diminished before complicated cataract makes its appearance   This fact is of the utmost importance from the prognostic point of view, since even if the cataract is successfully removed, the progressive diminution in vision due to changes in the fundus is not thereby influenced   In every doubtful case not only must the central and peripheral vision be carefully investigated, but an exhaustive search must be made for precipitates upon the back of the cornea

Treatment must be directed in the first case to the cause of the complication   This is often tedious and unsatisfactory, but must be persevered in as long as useful vision persists If then the perception and projection of light appear to be fairly good and the cataract is of a nature suitable for operation it should be removed by discission or extraction, according to the age of the patient   Many cases are not suitable for operation, mostly on account of cyclitis or the very defective vision and projection of light   Even in these, if there is a possibility of success operation may be undertaken after warning the patient of the doubtful issue, for the loss of such an eye weighs little against a reasonable probability of improved vision   It is wise in these cases to do a preliminary iridectomy (*vide* p 315)

Diabetic Cataract should be regarded as a form of complicated cataract   Cataract in diabetic persons is by no means always diabetic in the proper sense of the term   Senile cataract of the usual type, following the usual course, often occurs, and should be treated in the ordinary manner, though in the early stages the general disease must invariably receive every attention, both in the matter of diet and drugs   True diabetic cataract is comparatively rare, and occurs in younger

adult patients It is always bilateral and commences with small discrete cloudy opacities immediately beneath the anterior and posterior capsules (Fig 187) Dusty opacities then appear throughout the cortex and rapidly increase until total cataract supervenes A uniform milky opacity of rapid onset should always suggest the possibility of diabetes, though of course the urine should be tested as a matter of routine in all cases of cataract

Diabetic cataract, though usually occurring in patients with a large percentage of sugar in the urine is not immediately due to the mere presence of sugar in the aqueous, for it is never
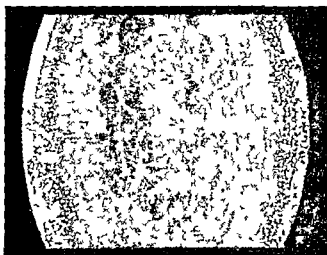
FIG 187 —Diabetic cataract   Optical section as seen with
              the slit lamp   (Goulden)

sufficiently concentrated to cause cataract *per se* Nevertheless, there can be little doubt that osmotic changes are a prominent factor in the pathogenesis and account for the accumulation of droplets beneath the capsule

Cataract is readily produced in rats by a diet containing large doses of lactose or galactose (but not dextrose) These sugars are said to aid absorption of calcium from the intestine, and it is noteworthy that there was an increase of calcium in the eyes with cataract, but no increase in the blood

Treatment It is imperative in all cases of true diabetic cataract to treat the general condition before adopting operative measures It is rare for the opacity to clear up under such treatment, but since cases do occur (Nettleship), and since

operations upon the eyes of diabetic patients have special dangers of their own this chance should always be afforded

If general treatment is unsuccessful the cataract must be extracted In spite of the special difficulties attending the operation the results are often quite satisfactory though a guarded prognosis should be given Contrary to what might be anticipated the wound usually heals well The special dangers are local and general Of the former the tendency to severe iritis and to hæmorrhage are the most important The necessary manipulation of the iris is likely to set up traumatic iritis of a peculiarly violent type Iridectomy in the course of the operation may be attended with much hæmorrhage which not only obscures the view of the field of operation but may endanger the eye violent intra vitreous or subchoroidal hæmorrhage may destroy the eye at the time of operation Hence it is desirable to remove a diabetic cataract by simple

extraction i e extraction without iridectomy or at any rate with only a peripheral button hole iridectomy (vide p 499) The chief danger affecting the general system in these cases is the risk of the sudden onset of diabetic coma It is comparatively slight and must be guarded against as far as possible by a suitable course of anti-diabetic treatment before operating Another grave danger is that of septic infection If it occurs panophthalmitis rapidly supervenes owing to the very defective resistance of the tissues

Fig 188 —Coloboma of the lens (Marcus Gunn) The direction of the coloboma upwards is somewhat unusual Note the defective development of the suspensory ligament of the lens

Traumatic Cataract See p 446

Persistence of the Posterior Vascular Sheath (Syn —Posterior Polar Cataract) See p 332

Glass workers Cataract occurs chiefly in men who have long been engaged in glass manufacture part cularly beer bottles and plate glass It does not affect those who make flint glass bottle or pressed glass art cles the heat of the furnaces be ng much less in these cases The cataract is very character stic In the early stages there is a small disc of opacity in the posterior cortex of the lens thinner and more sharply defined than the posterior cortical opacity of compl cated cataract b t it may extend throughout

the cortex in the later stages The radiations from the molten glass contain few ultra violet rays, which are therefore probably not the cause It is most likely that heat is the cause, acting, not directly on the lens, but upon the iris and ciliary body, thus influencing the nutrition of the lens As already stated (p 22), heat radiation is absorbed by the pigment epithelium of the iris, ciliary body, and retina Vogt has produced cortical cataract in rabbits by exposure to radiation of wave-length 670—700 μμ for less than an hour

It has recently been shown that certain *iron workers*, especially tin plate millmen and chain makers, suffer from an identical condition It is apparently rare in other iron workers, probably because they seldom look at the hot metal, and when doing so protect their eyes with coloured glass It does not occur among acetylene welders, &c , who are unable to carry out their work without efficient protection of the eyes by suitable deeply tinted protective goggles

Irradiation Cataract, due to exposure of X rays or radium, resembles the early posterior cortical stage of glassworkers' cataract One course of deep X rays may suffice There is a considerable latent period, which may be at least two years Only the γ-rays of radium seem to be nocuous

Perinuclear cortical opacities occur in the lenses of *Mongolian idiots* at about puberty Similar opacities also occur in cases of post-operative *tetany* and *myotonia atrophica* (*vide* p 599)

CONGENITAL ABNORMALITIES OF THE LENS

Besides the various forms of *congenital cataract* (*vide* p 320), abnormalities in the shape and position of the lens occur, often associated with other malformations of the eye

Coloboma of the lens is the condition in which there is a defect in the inferior margin, usually notch shaped , less frequently it occurs in some other part of the margin (Fig 188) It is due to defective development of part of the suspensory ligament

Ectopia lentis or congenital dislocation is a subluxation of the lens, usually upwards or up and in, and bilateral The condition is often hereditary The lens is small, but the edge is generally invisible until the pupil is dilated The usual signs of subluxation (*vide* p 436) are then seen It is sometimes associated with arachnodactyly

Lenticonus, generally posterior, is an abnormal curvature of the lens, so that the surface is somewhat conical instead of spherical. It is best studied by means of the slit-lamp

CHAPTER XVI

Diseases of the Vitreous

THE vitreous humour is an inert, jelly like structure which subserves optical functions (*vide* p. 10). It contains proteins and a muco protein. It has all the properties of a hydrophilic gel, undergoing turgescence in an alkaline, deturgescence in an acid aqueous medium. It is in very unstable equilibrium, and readily becomes transformed into a sol, either by mechanical means or chemical, *e g*, metabolic changes. Hence, " fluid " vitreous is a common pathological condition. It possesses no blood vessels in post natal life, and is incapable of becoming inflamed the old term " hyalitis " rests upon mis conception, and should be avoided. We have, therefore, to deal only with symptomatic conditions.

Opacities. Black specks, floating before the eyes, are seen by normal persons under favourable conditions. These *muscæ volitantes* are opacities of various kinds, viewed entoptically, i e, they throw a shadow upon the sentient elements of the retina, thus appearing as dark spots in the field of vision. Any relatively intransparent bodies situated anterior to the rods and cones are therefore able to produce muscæ. To this category belong the corpuscles circulating in the retinal blood vessels, if it were not for the fact that the retina is normally adapted for red light the entoptic images of the circulating corpuscles would be a serious impediment to clear vision. Other muscæ are due to minute specks in the vitreous, so small and so slightly intransparent that they cannot be seen objectively by the ophthalmoscope.

Under abnormal conditions muscæ may be so increased as to interfere with vision and to become visible by the ophthal moscope. They then indicate some disease of the uveal tract, particularly of the ciliary body. they are found in cyclitis, retino-choroiditis, myopia, &c. In their slightest manifesta tion they are dust like opacities, which may permeate the whole vitreous or be limited to the anterior part. When very fine a plane mirror and magnification by a convex lens are necessary in order to distinguish them (*vide* p. 110). They are

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due to minute albuminous coagula and aggregations of leuco
cytes, the former derived from the ciliary body and choroid,
the latter only from the ciliary body and possibly the retina
In the more severe cases flakes and threads are seen and the
entoptic images may be so sharply defined that an intelligent
patient is able to draw them accurately   The larger opacities
are often found after haemorrhage into the vitreous   They
almost invariably float about, showing that the vitreous is
fluid (*vide infra*) though they may be more or less anchored
to the retina   Vision is often best in the morning, before
the muddy vitreous has been stirred up by movements of the
eyes

Dense vitreous opacities obscure the view of the fundus with
the ophthalmoscope   In moderate cases the disc and vessels
may be made out, as if seen through a dense haze   The disc
looks redder than usual and it may be difficult to decide
whether there is papillitis or not

Very frequently in the slighter cases no objective signs of
disease can be made out in the fundus , the foci are either too
fine to be appreciated or are anterior to the field of ophthal
moscopic vision i e   in the anterior part of the choroid or in
the ciliary body

Treatment   Slight cases of muscæ volitantes without objec
tive signs, require no direct treatment   Patients should be
advised to ignore the spots as much as possible, as they are
often only visible when attention is specially directed to them
Any error of refraction should be corrected and special indi
cations as to the amount and conditions of near work should
be given   In many cases the patients suffer from gastro
intestinal disorders, which should be suitably treated

Treatment of the more severe cases of vitreous opacity
depends upon the cause   When this is known as in irido
cyclitis syphilitic retinitis retino choroiditis tubercle of the
uveal tract and so on, attention must be specially directed to
the treatment of the primary foci   The prognosis is best in
the syphilitic and the milder iridocyclitic cases

When the cause cannot be discovered iodides are generally
given, as they are supposed to promote absorption   They may
be combined with mercury, even in non syphilitic cases

The eyes should be kept at rest with atropine and dark
glasses   Hot bathings and leeches or dry cupping may be
tried , and subconjunctival injections have been beneficial in
some cases but must not be used if there is any active inflam
mation   Dionin has also been advocated

Fluidity of the Vitreous (*Syn —Synchisis* συγχεω, to pour together, disturb) is due to absorption of the fibrils and degeneration of the jelly like tissue, caused by some biochemical change in the vitreous gel. It is therefore a common feature in the cases in which opacities are present, and is associated with the same causes. It cannot be diagnosed with certainty in the absence of opacities, and is indicated by their free movements when the eye is rapidly moved. Fluidity of the vitreous may in some cases be simply a senile degeneration. The tension of the eye may be normal, but soft eyes nearly always contain fluid vitreous.

The degeneration of the vitreous which leads to fluidity often causes the deposition of crystals of cholesterin, which sink to the bottom of the vitreous chamber, but are stirred up by movements of the eye. They then appear as a very beautiful shower of golden rain—*synchisis scintillans*. There may be relatively little interference with vision.

Fluidity of the vitreous requires no treatment in itself, but it is a serious complication if any intraocular operation is contemplated. In such eyes the suspensory ligament of the lens is often weak, so that prolapse of the vitreous, dislocation of the lens, and so on may occur. Even when the vitreous pours out under these circumstances useful vision may yet be retained, the vitreous being replaced by lymph.

Blood in the Vitreous. Hæmorrhage into the vitreous may result from arteriosclerosis or inflammation of the retina, from contusions or wounds of the eye, diabetes, pernicious anæmia, malaria, &c, or without apparent cause. Small hæmorrhages are seen ophthalmoscopically and can be accurately watched, though the surrounding vitreous always contains exudates, unless the blood is subhyaloid (*vide* p 361). Larger hæmorrhages, filling the vitreous with blood, are suspected when no reflex can be obtained on throwing in light with the mirror. It may then be possible to see a red mass behind the lens by oblique illumination.

There is one form of severe vitreous hæmorrhage which occurs in apparently healthy young adults, usually males (*Eales disease*). It is probably due to a blood condition associated with defective coagulability. There is reason to think that tubercle is responsible for some of the cases, and endocrine disorders especially of the thyroid and pituitary body, for others. Some of the patients suffer from epistaxis. It has a great tendency to attack both eyes in succession and to recur, so that though absorption may be complete in the early

attacks permanent defect or complete loss of sight may ultimately follow from damage to the retina, retinitis pro liferans, or dense vitreous opacities It is characteristic of vitreous hæmorrhage that absorption usually takes place without organisation, owing to the absence of fibroblasts in the vitreous When organisation occurs, as in so called retinitis proliferans (*q v*), it is most marked near the disc, from which membranes and strands stretch forwards This is due to the presence of mesoblastic tissue, containing potential fibroblasts, around the central vessels Even then organisation rarely occurs in the absence of some general dyscrasia, *e g*, syphilis, nephritis, &c In other cases, therefore, the prognosis is good, bearing always in mind the tendency to recurrent hæmorrhage

Treatment Rest is imperative in all cases of vitreous hæmor rhage, and in the early stages the patient should be kept in bed Straining and stooping must be avoided as much as possible

In cases of recurrent hæmorrhage attempts may be made to increase the coagulability of the blood by the administration of calcium salts, the treatment being controlled by repeated estimations of the coagulation time The association of hæmor rhages with scurvy suggests the addition of fruits and vege tables containing vitamin C, or the administration of cevitamic acid (one or two tablets daily) Appropriate endocrine therapy should be instituted if specially indicated

Fibrous Tissue in the Vitreous is found in cases of plastic iridocyclitis, usually in the form of membranes stretching across behind the lens They cannot as a rule be seen clinically, as the lens is opaque

A subacute form of plastic endophthalmitis occurs in children and gives rise to one form of so called *pseudoglioma* It is often first noticed by the mother as a whitish reflex in the pupil (amaurotic cat's eye) Generally there is no knowledge of inflammation having occurred in the eye but a history may be obtained of fits, ear disease, an acute specific fever, post basic meningitis or some serious illness Several cases have been proved by pathological examination to have been due to the meningococcus There are usually signs of past iritis or iridocyclitis—posterior synechiæ &c The diagnosis from glioma is of great importance (*vide* p 424)

As already mentioned, recurrent hæmorrhages are liable to give rise to retinitis proliferans, which is really a formation of fibrous tissue in the vitreous

In some cases of this type, especially in syphilitic, gouty,

and possibly tuberculous subjects, minute bunches of new
formed blood vessels project from the disc or retina, usually
near the disc, into the vitreous (*vide* p 365)

Pus in the Vitreous   This is found only in panophthalmitis,
which is almost invariably due to a perforating wound or ulcer,
though cases of metastatic inflammation of the retina and
choroid also occur and lead to a similar result (*vide* p 341)
The reflex with the ophthalmoscopic mirror is poor or absent
Oblique illumination shows a yellow mass behind the lens   The
eye is always intensely inflamed, and little difficulty is usually
experienced in arriving at a correct diagnosis   The *treatment*
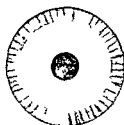
Fig 189—Opacity due
to persistence of part
of the posterior vas
cular sheath of the
lens often called pos
terior polar cataract
Note that the opacity
is usually more cir
cumscribed than in
posterior cortical cata
ract (Fig 186)
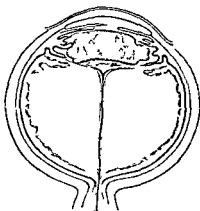
Fig 190—Diagram of persistent hya
loid artery, with persistence of the
posterior vascular sheath of the lens
(Treacher Collins)

in cases of exogenous infection is that of panophthalmitis due
to perforating injury (*vide* p 457)   In the rarer cases of endo
genous infection is that of the primary cause

Persistent Hyaloid Artery   The hyaloid artery, which in
fœtal life nourishes the vitreous and supplies blood to the
posterior vascular sheath of the lens, becomes obliterated
during the sixth and seventh months, and usually disappears
completely before birth   A remnant, stretching forwards
from its origin on the disc, is normal in oxen   Similar remnants
are not very rare in man   they appear as a strand projecting
from the disc into the vitreous   There may be membranes
veiling the disc from view in such cases   A remnant of the
anterior part of the hyaloid artery can be seen in normal

eyes, with the slit lamp, as a whitish coiled strand attached to the posterior capsule 1 to 2 mm to the nasal side of the posterior pole Sometimes a larger portion persists, appearing as a circular spot on the back of the lens, often inaccurately termed a *posterior polar cataract* (Fig 189) More or less of the posterior vascular sheath may persist in such cases, giving rise to a larger central opacity on the back of the lens In these cases there is always a gap in the posterior capsule of the lens and the adjacent posterior cortical lens fibres are cataractous The hyaloid artery may persist in its entirety with more or less of the vascular sheath (Fig 190) It may contain blood, and blood vessels may be seen upon the back of the lens, it is then liable to be mistaken for a glioma of the retina, and constitutes one form of pseudoglioma (*vide* p 421)

The appearance of the posterior part of the hyaloid artery, when persistent, is very characteristic A filmy, greyish cord, *sometimes containing blood, passes forwards from the disc towards the lens* It undergoes serpentine writhings when the eye is moved

When the hyaloid artery is persistent there is often defective or atypical development of the vitreous, part of which resembles fibrous tissue in structure Every stage may be met with, from that interfering little or not at all with vision to complete opacity, usually with maldevelopment of the whole eye—microphthalmia

Foreign Bodies in the Vitreous See p 451

Parasites in the Vitreous *Cysticercus* is excessively rarely found in the vitreous in England though it is less uncommon in some other countries The actual parasite may be seen ophthalmoscopically as a pearly translucent mass with peristaltic movements The treatment—removal—is very difficult

CHAPTER XVII

Diseases of the Choroid and Retina

It has already been pointed out that different parts of the uveal tract rarely suffer alone This intimate connection is most marked in the anterior parts, but clinically the evidence of cyclitis when the choroid is inflamed is slight, though not entirely wanting The outer layers of the retina are dependent for their nutrition upon the choroid, so that when the latter suffers the former is always involved secondarily Primary affections of the retina may occur without involvement of the choroid primary affections of the choroid invariably involve the retina secondarily in greater or less degree

This profound relationship between the retina and choroid, so indisputably manifested clinically, renders it advisable to consider their diseases in close connection with each other It will be found that some diseases commonly designated as "retinitis" are in reality secondary to a primary choroiditis while others are also included under the same term are not inflammatory, as is suggested by the word It is well, therefore to bear in mind that "retinitis" is used in a broad sense The same ambiguity is noticed in the use of the term "choroiditis," which frequently designates a degenerative condition without any evidence of inflammation

PRIMARY AFFECTIONS OF THE CHOROID

Vascular Disorders Although the blood supply of the uveal tract is almost entirely derived from the posterior ciliary arteries the peculiar distribution resulting in the formation of the circulus arteriosus iridis major causes involvement of both iris and ciliary body in pathological vascular conditions whereas choroidal lesions are often restricted to isolated areas Sclerotic changes in the choriocapillaris, for example may be sharply delimited as in macular degeneration, &c , and doubtless many of the patches of so called choroiditis and choidal degeneration are of vascular origin Some are probably due to embolism or thrombosis, but have rarely been proved so by histological examination Localised choroidal hæmorrhages occur, but are difficult to diagnose from the rounded retinal hæmorrhages posterior to the vessels (*vide* p 362) Massive

hæmorrhages from the choroid occur in expulsive hæmorrhage (*vide* p. 501).

Inflammation affecting the choroid primarily—*choroiditis*—occurs in two forms, exudative and suppurative. The former appears in the form of isolated foci of inflammation scattered over certain areas of the fundus, and is conveniently classified according to the position of the areas involved. The latter spreads over the whole choroid and retina, and the primary seat may be in the retina : it leads ultimately to panophthalmitis.

Exudative choroiditis is often syphilitic in origin, though certainly not so generally as was formerly thought, it affects chiefly either the posterior part of the fundus—disseminated choroiditis—or the anterior part—anterior choroiditis.

Disseminated Choroiditis may be taken as a type of the disease (Plate IX., Fig. 1). The recent foci are seen ophthalmoscopically as round yellowish spots, when near a retinal vessel they lie at a deeper level than the vessel. They are due to infiltration of the choroid, the exudates hiding the choroidal vessels which cause the normal red reflex. In the early stages the elastic membrane of Bruch is intact ; in these circumstances only fluid exudates can pass through it, but these suffice to make the overlying retina cloudy and grey. Hence the edges of the spots are a little hazy and ill-defined. The exudates not only pass into, but also through the retina, so that punctate or diffuse opacities are seen in the vitreous When the vitreous haze is excessive the ciliary body is also probably involved. In later stages the membrane of Bruch may be absorbed, though it offers considerable resistance in common with all elastic membranes.

Fig 191.—Atrophy after syphilitic choroiditis (Nettleship, after Hutchinson) *a*, atrophy of pigment epithelium , *b*, atrophy of epithelium and choriocapillaris, exposing the large choroidal vessels ; *c*, spots of complete atrophy, many with pigment accumulation

When this has occurred leucocytes are enabled to pass through into the retina and vitreous.

Owing to the fibroblastic activity of the choroidal stroma the exudates become organised, so that a small white mass of fibrous tissue is formed, which destroys the normal structures of the choroid and retina and fuses the two membranes firmly together The colour of the spots therefore gradually changes to white partly due to the fibrous tissue deposited partly to thinning and atrophy whereby the white reflex from the sclerotic is permitted to shine through (Fig 191)

The pigment of the retinal pigment epithelium is extremely
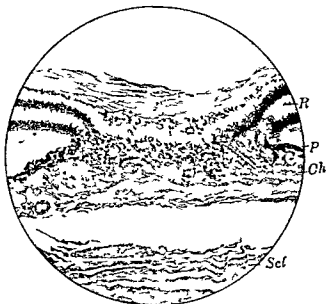
FIG 192—Section of a patch of disseminated choroid tis showing the fus on of the degenerated retina (*R*) and choroid (*Ch*) (× 60) Note the heaping up of the retinal pigment epithel um (*P*) at the edges of the adhes on *Scl* sclerotic

resistant even though the cells which contain it be destroyed It tends to become heaped up into masses, partly intra , partly extra-cellular   moreover the pigment cells are stimulated to proliferate Isolated masses of black pigment are thus formed in the white areas but more particularly at the edges so that in the atrophic stage white spots surrounded by a black zone of pigment are seen (Fig 192) The process has then reached its natural termination and these spots remain permanently almost unaltered They are much more sharply defined than the actively inflammatory spots

Meanwhile fresh foci arise and pass through the same stages until finally the whole fundus may be covered with atrophic spots In the milder cases only a few spots are formed and the exudates in the vitreous become absorbed In the more severe the spots are very numerous, the vitreous opacities increase, and finally the nutrition of the lens suffers and a complicated cataract (q v) results Owing to the transiency of the acute stage the atrophic stage naturally comes much more frequently under observation

The symptoms in the early stages are principally the defects of vision due to the retinal lesions and to cloudiness of the vitreous The spots are slightly raised, so that the contour of the retina is altered This causes distortion of the images, giving rise to similar appearance of distortion of the objects seen—metamorphopsia thus straight lines appear to be wavy or bent in various directions Frequently objects appear smaller than they are—micropsia, sometimes larger—macropsia these results are due to separation or crowding together respectively of the rods and cones They are not likely to be noticed unless the macular region is involved Subjective symptoms of light—photopsiæ—occur, such as flashes of light due to retinal irritability These subjective symptoms are often accompanied by the perception of a black spot in front of the eye, corresponding with the lesion—*positive scotoma*

In the later stages the affected spots are incapable of giving rise to visual impulses, so that *negative scotomata* exist in the field of vision, i e , though there is no perception of a spot in front of the eye there is a hiatus in the field of vision of the same nature as the normal blind spot Their relative importance depends upon their situation Peripheral scotomata may pass unnoticed, central scotoma destroys direct vision, in the latter case peripheral vision still permits the patient to get about well, but all fine work is impossible

The disease is chronic, organisation of the exudates taking several weeks The occurrence of fresh spots may extend the acute stage over months, and the ultimate defects are permanent

The disease is usually due to syphilis, generally acquired, sometimes congenital, and hence associated frequently with interstitial keratitis , but in many cases the cause is obscure, sepsis anæmia and disorders of nutrition being assigned The changes produced by myopia cause similar signs and symptoms , they are not inflammatory, but degenerative from the commencement (Chap XXIV)

Treatment is primarily that of the ætiological factor—syphilis or such cause as can be discovered   Iodide of potassium may assist absorption in all cases, and should be administered   The general regime advised for cyclitis (*q t*) is suitable in these cases   Marked irritative symptoms indicate the use of dark glasses the abandonment of all near work, and some times the application of leeches

Anterior Choroiditis is also usually syphilitic, and manifests itself in the same form as disseminated, but is confined to the peripheral parts of the fundus   On this account it is frequently discovered only by the ophthalmoscope   Similar changes are also sometimes found in high myopia   Simple pigmentary changes at the periphery occur in old people as a senile degeneration

The periphery of the fundus is often peppered over with minute spots of pigment in congenital syphilitics, this is possibly a purely retinal affection   It can only be distinguished by degree from a similar pigmentation which may be a mere idiosyncrasy

Central Choroiditis occurs in disseminated choroiditis, and in certain rare forms   In Forster's areolar central choroiditis the spots are said to behave in exactly the opposite manner to those of disseminated , they are first black, then enlarge, becoming white in the centre and finally quite white   The disease extends outwards, the peripheral spots being always the most recent

Juxtapapillary Choroiditis (*Retinochoroiditis juxtapapillaris*) (Jensen) occurs in young persons, as an exudation close to the disc   oval in shape and about the same size as the disc   The exudates cover the retinal vessels, and there are vitreous opacities and sometimes   k p "   There is a sector shaped defect in the field of vision   The cause is unknown   The inflammation slowly subsides leaving a patch of atrophy   Recurrence may take place

Diffuse Choroiditis is characterised in the early acute stage by one or more plaques of yellowish white or grey areas shading off at the edges into normal fundus   The patches spread and coalesce so that the greater part of the fundus may be finally involved   The exudates gradually organise, leaving white areas in which the larger choroidal vessels persist, as a characteristic band like network   The retinal pigment becomes heaped up into dense black, irregular spots, variously grouped   The retinal vessels course over the patches little changed in appearance   The coalesced areas leave islands and spaces of

normal fundus between them when organisation is complete
Fresh exudates occur simultaneously with the organisation of
older ones, and sometimes the edge of a patch appears to creep
over the fundus like the advance of a *myxomycetes*

Some of these cases are syphilitic, some tuberculous (*q v*)
In others the cause cannot be traced, but probably many are
due to metastatic bacterial invasion (*vide infra*, Metastatic
Endophthalmitis)

Purulent Choroiditis. See p 457

Tubercle of the Choroid occurs in acute or miliary and chronic
forms   Miliary tubercles are found in the late stages of acute
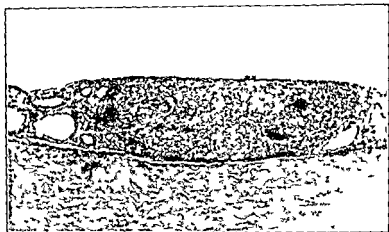
FIG 103 —Section of miliary tubercle of the choroid (× 60) from a
child with hip disease who died of meningitis   Note the giant cells
and the small round cells at the periphery

miliary tuberculosis, especially tuberculous meningitis   Occa-
sionally they may be seen before there is any evidence of
meningitis or generalised tubercle   They are very common in
the late stages of tuberculous meningitis in children, though
they may appear only a day or two before death   My own
observations, clinical and post-mortem, lead me to think that
they are nearly always present in this disease   Ophthalmo
scopically they appear as *round, pale yellow spots*, most fre-
quently observed in the neighbourhood of the disc, though
any part of the choroid may be attacked   Generally only three
or four spots are seen, but as many as sixty or seventy have
been found   They vary in size from pin point specks to 1 or
2 mm in diameter   They usually project slightly, so as to

raise the retina but the inner surface is often quite flat, while the outer surface projects into the sclera They afford most important diagnostic evidence of tubercle in cases of meningitis and obscure general disease Microscopically they consist of typical giant-cell systems, containing a variable number of tubercle bacilli (Fig 193)

Chronic tubercle of the choroid may occur as a diffuse inflammation affecting large areas or the whole choroid, and characterised by the extensive development of granulation tissue , or, more rarely as a solitary or conglomerate mass, simulating sarcoma but usually showing definite signs of inflammation, e g , œdema of the retina, vitreous opacities, &c The diffuse form shows ophthalmoscopically areas raised some what above the surrounding fundus covered by œdematous retina, and with hazy edges There are usually vitreous opacities The mass consists of granulation tissue containing giant cells spreads until it involves the retina and may finally fill the posterior part of the globe Similar ophthalmoscopic appearances are met with resulting from metastatic choroiditis (q ι), and from changes following localised hæmorrhage into the deep layers of the retina (so-called " massive exudation " in the retina (vide p 373)) von Pirquet's test or injection of tuberculin may afford help in the diagnosis Such cases were formerly all diagnosed as tubercle of choroid but this is certainly not the case They occur both in children and young adults, and may subside, particularly in the latter, leaving large areas of choroido retinal atrophy Possibly the cases which behave thus are not really tuberculous

Certainly true tubercle of the choroid may extend indefinitely, especially in children, and the conglomerate type usually does so The sclerotic becomes involved, perforation takes place, usually near a vortex vein or an anterior perforating ciliary vessel, a fungating mass appearing under the conjunctiva Both types in very young children may nearly simulate glioma of the retina (especially glioma endo phytum (q ι)), constituting one form of pseudoglioma (q v)

Treatment No local treatment is indicated in miliary tubercle of the choroid The patient quickly succumbs to the general disease In diffuse and conglomerate tubercle treatment with tuberculin should be instituted in the early stages, but if the eye is extensively involved it is best to enucleate it and thus remove a dangerous focus from which the organism may be disseminated into the system Diathermy, as used in

detachment of the retina (q v) has been used for conglomerate tubercle (Wexe)

Metastatic Endophthalmitus Endogenous bacterial infection of the eye manifests itself in various ways Most commonly the uveal tract is affected either as a whole (metastatic uveitis) or in its individual parts as for example in gonorrhoeal iritis The milder forms of iridocyclitis (q v) and uveitis are probably due to toxins circulating in the blood stream, and derived from bacterial foci in other parts of the body, e g , the mouth, the generative apparatus especially in women the intestinal tract and so on It is certain however from anatomical examination, that actual bacterial embolism occurs and in these cases two facts stand out prominently First various organisms show a special selectivity for the various structures of the eye Thus the tubercle bacillus never attacks the retina primarily though this structure is often involved secondarily in tuberculous disease of the choroid Second except in the case of extremely virulent organisms such as the streptococcus the inflammation set up by endogenous infection is usually less severe than when the organism is introduced directly into the eye from without Thus if the eye is infected with pneumococci by a perforating wound an exogenous panophthalmitis (q v) is likely to be set up leading to the complete destruction of the organ So much is this the case that saprophytic organisms, such as the bacillus subtilis which are non pathogenic in other parts of the body, may cause panophthalmitis If, however, an organism such as the pneumococcus invades the eye by way of the blood stream, though an intense inflammation results it tends to subside more rapidly than in the exogenous cases Probably the organism becomes attenuated in the blood stream and tissues through the controlling effect of specific antibodies In this manner virulent bacteria may set up endophthalmitis of every grade of severity In the days when puerperal sepsis was prevalent intense metastatic panophthalmitis often attacking both eyes was not uncommon It was characterised by the appearance of an hypopyon and the rapid development of a yellow pupillary reflex due to pus in the vitreous Less tense metastatic uveitis involving the ciliary body and iris, and due to bacterial invasion was set up Such cases progressed exactly like ordinary exogenous panophthalmitis (q v)

They are now seldom seen but cases of metastatic uveal invasion often of obscure origin still occur in which an early stage of uveitis with hypopyon is present They occur in the course of infectious diseases especially pneumonia rheuma-

measles and scarlet fever, and of meningitis, dysentery, &c Ophthalmoscopically the media are hazy, so that the yellow œdematous retina is only dimly seen Under treatment the condition gradually subsides, not infrequently with the restoration of useful vision In more severe cases the inflammation causes destruction of the ciliary processes the intraocular tension falls and the eye gradually shrinks In children the inflammation is probably often due to the diplococcus intra
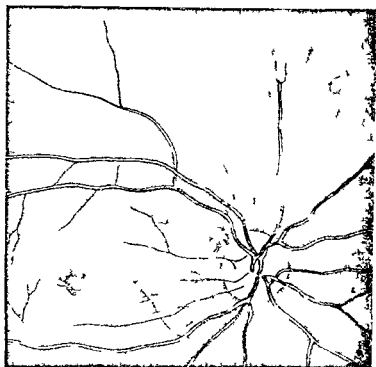
FIG 194 —Metastat c choro d tis

cellular of Weichselbaum and is followed by an exuberant development of new fibrous tissue of cyclitic origin These cases are not easily distinguished clinically from glioma, and form the largest group of so called pseudoglioma (*q v*) In the milder cases there is less development of cyclitic fibrous tissue in the vitreous and less scarring of the retina, but whitish atrophic spots and areas accompanied by pigment disturbance persist as evidence of the previous inflammation Yet milder cases give rise to ophthalmoscopic appearances which may be

mistaken for diffuse or conglomerate tuberculous diseases of the choroid (*q v*) (Fig 194), or thrombosis of a branch of the central vein of the retina In some cases the optic papilla has been the chief local focus, and an appearance of intense papillitis with much exudation extending into the neighbouring retina is seen Some of the cases have been associated with furunculosis, and there is little doubt that they are due to metastatic infection with staphylococci Others have been proved to be due to the pneumococcus, meningococcus, &c Other obscure cases of retinitis with white spots or oval areas, usually near the disc, with or without hæmorrhages, are probably due to the same cause

The presence of precipitates ("k p") on the back of the cornea and inconspicuous posterior synechiæ shows that in many cases of apparently localised endogenous choroiditis the whole uveal tract is really involved (uveitis).

The *treatment* depends upon the severity of the attack, and the possibility of determining the primary focus and the specific organism In the worst cases the patient should remain in bed, and purgatives and the drugs for the relief of pain should be administered Hot applications should be made and atropine instilled Sulphonamide treatment may be tried (*vide* p 669) If the eye becomes full of pus it should be enucleated or eviscerated according to the principles which govern the treatment of panophthalmitis of exogenous origin (*q v*)

In the milder cases purgatives and general tonic treatment are indicated Atropine should be instilled to keep the eye at rest, and dark glasses worn Counter irritation with leeches or blisters to the temple may be indicated If the primary source of infection can be discovered it must be treated radically If the organism can be isolated vaccine treatment is indicated, and in the more obscure cases treatment with a polyvalent vaccine may be of some avail

Suppurative or Purulent Choroiditis See Metastatic Endophthalmitis (p 341) and Panophthalmitis (p 457)

Degenerative Changes may be post-inflammatory or primary The former, culminating in localised spots of complete atrophy, have already been considered Generalised atrophy, more or less complete, is found in the later stages of glaucoma The loss of nourishment to the retina causes atrophy of the outer layers and of the nerve fibre layer in these cases Degenerative changes in the choroid often cause migration of pigment from the pigment epithelium into the more superficial parts of the retina The pigment tends to become deposited in the peri

vascular lymph spaces of the veins, so that the retinal veins may be mapped out here and there by pigment   More noticeable ophthalmoscopically are yet black branched spots of pigment, resembling bone corpuscles, and standing out in sharp relief   This condition is seen in its most typical form in "retinitis" pigmentosa, which is in reality due to primary choroidal atrophy   An almost identical picture, though usually without the characteristic distribution of the pigmented spots, may result from choroidal atrophy due to other causes, e g, syphilis   This migration of pigment into the retina is shown to be due to interference with the choroidal circulation by the fact that it occurs after division of the short ciliary vessels in rabbits

Primary choroidal degeneration may be localised or general

Fig 195 —Section of   colloid bod es seated upon the membrane of Bruch   They are undergoing calcification as shown by the deeper staining in the inner parts   They are covered with stretched pigment epithelial cells

the best example of the latter is so-called retinitis pigmentosa, which will therefore be considered here

Localised choroidal atrophy, apart from the post inflammatory forms is usually either central or circumpapillary

Central choroiditis, or more properly *central choroidal atrophy,* is most commonly the result of myopia (q v), syphilis, contusion (Chap XXI) or old age

Senile central choroidal atrophy assumes two chief forms   In *central guttate choroiditis* (Ta\ s choroiditis) there are numerous minute yellowish white spots in the macular region (Plate X Fig 1)   They may increase in numbers, but otherwise they remain stationary   They are always small, usually round, but the larger spots may have crenated edges, thus showing signs of fusion   There may be indefinite signs of greyish pigmentation of the edges of the spots, due to the fact that the pigment epithelium is stretched over them (Fig 195)   The

PLATE X

FIG. 1. Tay's choroiditis

FIG. 2. Central areolar choroidal atrophy

PLATE XI
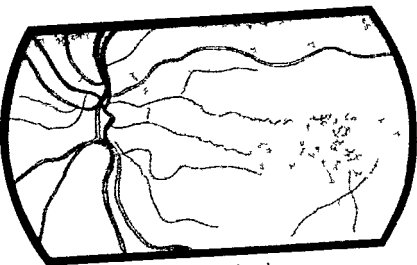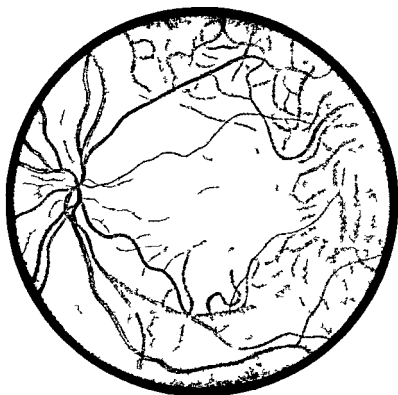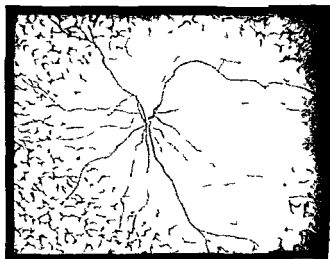
Fig 1 — Retinitis pigmentosa
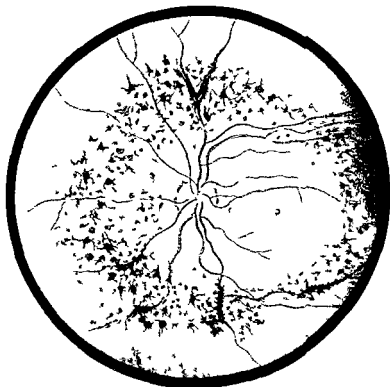
Fig 2 — Retinitis pigmentosa

condition is bilateral   They have been mistaken for diabetic
or albuminuric retinitis (q v) and retinitis punctata albescens
(q v)   They are easily distinguished from the former, in which
the spots are much brighter and more glistening, and are often
arranged in the form of a fan or star , and from the latter, in
which the spots are not limited to the macular region and are
much whiter   In neither case is there any obvious disturbance
of pigment   Central guttate choroiditis causes *per se* little
impairment of vision, but other senile changes are often present
and account for defective sight   The spots are due to peculiar
hyaline excrescences on the surface of the choroid commonly
known as *colloid bodies* (Fig 195)   They are of the same nature
as Bruch's membrane and like it are secreted by the pigmented
epithelial cells

Central areolar choroidal atrophy—to be carefully distin
guished from Forster's areolar choroiditis (*vide* p 338)—
appears as a large circular or oval patch of degeneration in the
macular region in which the choroidal vessels are visible,
owing to atrophy of the retinal pigment epithelium (Plate X
Fig 2)   As a result of atrophy of the choroid the sclerotic
shines through and the patch is white though traversed by
choroidal vessels   Only the larger choroidal vessels are seen
the smaller ones having disappeared and even the large ones
appear smaller than usual owing to degeneration of the walls
There is an absolute central scotoma   The condition is to be
feared in cases of cataract in which perception of light seems
defective   hence the great importance of investigating the
fundus thoroughly in cases of immature cataract   It is possible
that this form of central choroidal atrophy is due to extravasa
tion of exudates

Besides these conditions and much commoner, minute
changes limited to the area at and immediately around the
fovea centralis occur not infrequently in old people and lead
to grave disturbance or abolition of central vision (*central senile
macular degeneration*)   It is generally necessary to dilate the
pupil with cocaine or homatropine in order that they may
be seen, care being taken to instil eserine when the examination
is finished (*vide* p 310)   When central vision is very poor in
an elderly patient and no cause can be found to account for the
defect, such as error of refraction, tobacco amblyopia, cataract,
glaucoma &c , pathological changes will probably be found
at the macula   In the early stage the fovea is surrounded by
a ring of very fine pigment spots   The stippling is more
sharply defined on the foveal side, which usually has a circular

or crenated edge, it diminishes rapidly peripherally, where the fundus becomes normal The fovea gradually becomes paler in colour and the stippling denser, the change being associated with increasing failure of vision, until eventually the small central scotoma becomes absolute The progress is usually slow Both eyes are affected, but one is usually attacked before the other, and many months may intervene It is generally attributed on slender evidence to septic absorption, and by others to prolonged action of ultra violet light

Sometimes a round white or yellowish patch, about the size of the disc is seen at the macula and may be bilateral The patient is usually old with obvious disease of the retinal vessels Some of these patches undoubtedly follow hæmorrhages

Treatment The treatment of these degenerative changes is very unsatisfactory When central senile changes are seen early the treatment of any source of sepsis, e g, pyorrhœa alveolaris should be carried out Strychnine, thyroid extract and general tonic treatment is usually applied, but without much success Smoking should be prohibited (*vide* p 375) The patient s mind may be relieved to the extent that the rest of the field of vision is not likely to become affected, so that, although unable to read or do fine work, he can get about freely In the early stages reading is facilitated by the use of a black mask in contact with the paper and exposing only one line of print, or by the use of a magnifying glass, especially a "reading crystal," i e, a plano convex lens in contact with the paper

Circumpapillary Choroidal Atrophy is found in myopia (q v) and in late stages of glaucoma

"*Retinitis*" pigmentosa is an extremely chronic, progressive degeneration of the choroid and outer layers of the retina in both eyes beginning in childhood and often resulting in blindness in middle or advanced life The choriocapillaris suffers first so that the nutrition of the outer layers of the retina fails early The degeneration commences in a zone near the equator of the eye, and gradually spreads both anteriorly and posteriorly The macular region is not affected until very late in the disease The condition is bilateral The peculiar site of origin has been attributed to the relatively weak choroidal circulation in this zone, which is the meeting place of the short ciliary and the recurrent ciliary arteries (*vide* p 13)

The symptoms of the disease are very characteristic, the most prominent being defective vision in the dusk (night blind

ness) (*vide* p 412) This symptom may be present several years before pigment is visible in the retina Vision under low illumination is carried on essentially by the rods (*vide* p 68) and night blindness is a sign of defective nutrition of these structures, which from their situation suffer first in disease of the choroid

Examination of the vision may show perfect central visual acuity Investigation of the field of vision, seldom satisfactory in children but more reliable in young adults, shows
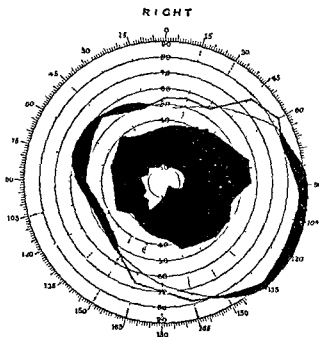
Fig 196 —Ring scotoma, from a case of retinitis pigmentosa

concentric contraction of the fields, specially marked if the illumination is reduced In early cases a partial or complete annular or ring scotoma is found (Fig 196) corresponding to the degenerated zone of retina As the case progresses the field becomes continually slowly smaller, until at last it is reduced to a small area round the fixation point Central vision may even now be normal but the patients are quite incapacitated from getting about, for they are in much the same condition as a person looking down two long cylinders—they see only the thing they are actually looking at and nothing around They therefore grope about helplessly Loss of

central vision does not usually occur until fifty or sixty years of age, but vision may be lost earlier through cataractous changes occurring in the centre of the posterior cortex of the lens

Ophthalmoscopic examination shows also a very characteristic picture (Plate XI) In the zone affected the retina is studded with small jet black spots, resembling bone corpuscles or spiders The retinal veins, never the arteries, often have a sheath of pigment for part of their course (*vide* p 344, Plate XI, Fig 2) As the pigment from the retinal pigment epithelium migrates into the superficial layers the epithelium itself becomes decolorised, so that the choroidal vessels are now visible and the fundus appears tesselated The pigment spots which lie near the retinal vessels are seen to be anterior to them, so that they hide the course of the vessels There is no question therefore, as to their exact position in the retina itself In this respect they differ from the pigment around spots of choroidal atrophy (*vide* p 336) in which the retinal vessels can be traced over the spots The number of pigment spots differs much in individual cases and they are often very scanty in the early stages

In the earliest stages it can be proved that it is a zone of the retina which is affected and not the most anterior part, for normal retina may be seen at the peripheral limits of the ophthalmoscopic field In the later stages this area diminishes *pari passu* with extension of the disease towards the centre

The retinal blood vessels, both arteries and veins, become extremely attenuated and thread like

As the pigmentation increases and the retina becomes more and more atrophic the ganglion cells are destroyed, thus leading to degeneration of their axis cylinders, viz , the fibres in the nerve fibre layer of the retina and the fibres in the optic nerve Optic atrophy, therefore, sets in and gradually increases The disc exhibits the characteristics of primary optic atrophy (*vide* p 397), but is not quite typical of this condition The disc is pale, but seldom more than yellowish white, like wax there is no excess of fibrous tissue, but the vessels are very small and thread like

In the later stages the nutrition of the lens suffers The complicated cataract which is formed is a very typical form of progressive posterior cortical cataract, going on to complete opacification of the cortex

Only a few late cases have been examined microscopically In all it has been found that the choroidal vessels show very

extensive endovascular degeneration   The same applies to
the retinal vessels, but probably these are less affected in the
early stages

The cause of retinitis pigmentosa is unknown   Several
members of the same family are often affected, consanguinity
of the parents is not infrequent, and the disease may affect
several generations   Nettleship found heredity without
consanguinity in 23 per cent , consanguinity without heredity
in 23 per cent , and heredity combined with consanguinity in
3 to 4 per cent   The patients or other members of the family
are found not infrequently to suffer from insanity epilepsy,
or other signs of mental debility   About one third of the
patients are deaf, and 4 per cent of deaf mutes have retinitis
pigmentosa (Nettleship)   Evidences of cerebral disease or of
congenital anomalies in the eyes or other parts of the body
(harelip, &c) may be present   it may also be associated with
obesity, hypogenitalism, mental defect and polydactyly
(Laurence Moon Biedl Syndrome)   Congenital syphilis may
produce similar results, though these cases are seldom quite
typical (*vide* p 344)

In syphilitic chorioido retinitis exactly the same ophthal
moscopic appearances associated with night blindness may
occur and may be present in both eyes   These cases are rare
and can be distinguished by the later onset of night blindness
and the absence of the disease in other members of the family
Much more commonly in syphilis the patches are limited to
certain areas of one or both retinae   The prognosis is better in
the syphilitic cases, since they may become stationary   It is
best to restrict the term "retinitis pigmentosa" to the very
typical congenital and familial disease

Pathology   The opportunity to examine microscopically eyes
with retinitis pigmentosa seldom occurs   In the cases on record
the retinae, especially their outer layers are very atrophic and
contain masses of pigment which have migrated from the pigment
epithelium   The choriocapillaris of the choroid is absent under
the affected areas   there is some doubt as to degenerative changes
in the larger choroidal vessels, which sometimes appear to be
little changed   It has been proved experimentally on rabbits
that section of short posterior ciliary arteries is followed by
pigmentary degeneration of the retina quite similar to retinitis
pigmentosa, in the areas lying over the parts of choroid supplied
by these vessels   This is strong evidence in favour of the view
that the disease is primarily due to interference with the choroidal
circulation   Treacher Collins however has advanced the theory

that the disease is due to abiotrophy of the neuro epithelium analogous to abiotrophy (Gowers) of the central nervous system —a term which explains nothing

Treatment is eminently unsatisfactory, since nothing appears to have a decided influence upon the course of the disease Trephining at the corneo scleral margin has been followed by temporary improvement (Mayou), probably by improving the intraocular circulation Extraction of the lens may be followed by some improvement in vision but should not be done until a late stage is reached Attention should be paid to the general nutrition since it has been proved that defective formation of visual purple, and consequent night-blindness may follow a diet poor in vitamin A, hence cod liver oil halibut oil or carotene in oil should be given Attempts to improve the circulation by vasodilators, *e g*, acetylcholine and by removal of the superior cervical ganglion have proved useless

Retinitis pigmentosa sine pigmento is a variety of the disease with the same symptoms but without visible pigmentation of the retina It is almost certainly only the early stage of the ordinary disease (Nettleship) It is progressive and leads to optic atrophy therein differing from *congenital night blindness*, which is a rare hereditary disease without ophthalmoscopic signs remaining stationary throughout life

Allied to these conditions is *retinitis punctata albescens* in which with the same history and symptoms, the retina shows hundreds of small white dots distributed fairly uniformly over the whole fundus The condition is almost certainly an atypical variety of retinitis pigmentosa, and may occur in a family affected with this disease It differs in the important fact that it is almost if not quite non progressive, but one case is on record in which the white spots disappeared and typical pigment spots developed (Nettleship)

Detachment of the Choroid The choroid is often found detached from the sclerotic in eyes which have been lost by plastic iridocyclitis, glaucoma, &c Detachment may also occur from severe hæmorrhage or new growth These cases cannot be diagnosed clinically Fuchs has shown that the condition is not uncommon after iridectomy for glaucoma and cataract extraction, and attributes it to slight separation of the ciliary body, so that the aqueous percolates from the anterior chamber into the suprachoroidal space It occurs during the first days after the operation The anterior

chamber is shallow or abolished, and on ophthalmoscopic examination the detached choroid is seen as a dark mass behind the lens It may be visible as a dark brown mass by oblique illumination. Detachment of the choroid occurs not infrequently after trephining for glaucoma. The prognosis is usually good, the choroid becoming replaced and the anterior chamber re-established.

Sarcoma of the Choroid. See p. 418

PRIMARY AFFECTIONS OF THE RETINA

Primary Retinitis, in its most severe manifestations, is almost always the result of some general disease, and should, therefore, be properly regarded as a symptomatic disease. The metabolic changes in the retina are so rapid that it seems almost immune from fatigue in the proper sense of the word , hence retinal fatigue plays little or no part in causing asthenopia (*vide* p. 528) It is probable that slight inflammation of the retina may be caused by overuse or misuse of the eyes, but though some of the symptoms may be ascribed to it, ophthalmoscopic signs are wanting or so little marked as to be ambiguous. Thus, *hyperæmia* of the retina is often described, but can never be diagnosed with certainty in the absence of definite pathological signs in the retinal vessels (*vide infra*)

Retinitis in general gives rise to the following symptoms and signs, only some of which need be present in individual cases. There is usually some change in visual acuity. Rarely it is increased in the early stages , more commonly it is diminished throughout There may be concentric diminution of the field of vision, or scotomata may be present corresponding with the areas specially affected. There may be metamorphopsia, micropsia, or macropsia (*vide* p. 337) The light sense is diminished and photophobia may be present. Pain is almost invariably absent, though discomfort may be experienced.

The ophthalmoscopic signs may be diffuse or localised There may be general œdema, manifesting itself as a faint, diffuse haze, obscuring details, so that the normal bright red appearance is replaced by a paler cloudiness, often with definite white streaks, especially along the course of the vessels ; or there may be circumscribed areas of exudation. The latter appear as white spots, discrete or confluent, or yellowish plaques, varying in size They are not pigmented and the edges are ill-defined, so that there is little danger of mistaking them for patches of choroidal atrophy. The blood vessels usually show marked changes. The veins are

distended often irregular, darker than normal, and tortuous, the arteries are less altered, but the finer branches are also tortuous Hæmorrhages are common, though they are not in themselves evidence of primary retinitis When occurring in the superficial layers they are flame shaped with feathery edges, situated particularly along the course of the vessels, when in the deeper layers they are round, with better-defined contours

The optic nerve, being in anatomical and physiological continuity with the retina, often suffers with it, when this occurs to a marked extent the condition is called *neuro retinitis* The margin of the disc is then obscured and often shows a radial striation The disc is red, and may be measurably swollen, though seldom, if ever, so much as in the condition known as choked disc

Retinal atrophy, which follows severe retinitis, is shown by permanent whitish or yellow opacity, with diminution in the size of the vessels, which are often bordered by white lines The optic disc may show all the signs of advanced atrophy (*vide* p 398)

It has already been pointed out that retinitis is most frequently the symptom of an internal disease It is therefore usually bilateral The diseases most commonly causing the condition are syphilis, vascular disease, nephritis, diabetes, and leucæmia

The *treatment* of retinitis consists in giving the eyes complete rest and in combating the general disease which is the cause All near work is forbidden and the eyes are protected with smoked glass, or even confinement in a darkened room Whether due to syphilis or not, mercury and iodides are given with a view to aiding the absorption of exudates and restoring the transparency of the vitreous if this is affected Mercury is contra indicated in renal retinitis These means are supplemented by purgatives, diaphoretics, and tonics

The blood vessels of the retina are peculiarly subject to disease in retinitis, partly as a factor in the inflammation, but more prominently as a concomitant of general disturbance or disease It will be well, therefore, to discuss the commoner forms of vascular disease of the retina before passing on to describe the chief types of retinitis in greater detail

Vascular Disorders of the Retina

Anæmia may be part of general anæmia or due to local causes It may be sudden or slow in onset Sudden anæmia is seen in embolism of the central artery of the retina (*q v*)

and in quinine amblyopia (*q.v.*). Ophthalmoscopically there
is great attenuation of the retinal vessels and the optic disc
is pale. Spasmodic constriction of the retinal arteries has been
described in migraine (*vide* p. 411), but it is doubtful if it
occurs. I have seen one case of spasm of the retinal arteries
in one eye, giving rise to the symptoms of embolism of the
retinal arteries : it passed off during the actual ophthal-
moscopic examination. The retinal vessels constrict under
high oxygen concentration in the blood, and dilate in anoxæmia.
Anæmia of slow onset is seen in atrophy of the retina from
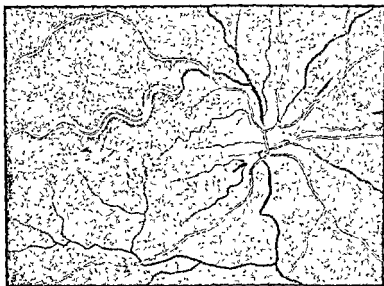
Fig. 197.—" Copper-wire " arteries, degeneration of the walls of a vein,
and white spots of degeneration.

any cause, such as previous retinitis, and in disease of the
vessel walls as part of a general vasculitis. In both cases the
vessels are attenuated, and sometimes in the former, and
commonly in the latter, the walls become thickened and
visible as white lines bordering the red blood stream ;
eventually the vessels may be transformed into white strands
or may even disappear.

Embolism of the Central Artery of the Retina causes sudden
and complete retinal anæmia. The retina in rabbits dies within
half an hour after complete blockage of the central artery,
but probably survives longer in man. The eye, usually the left,
becomes suddenly quite blind. Examination of the fundus

reveals a very typical picture (Plate XII., Fig. 1). The larger arteries are reduced to threads, the smaller are invisible. The veins are little altered except on the disc, where they are contracted. Within a few hours the retina loses its transparency, becoming opaque milky-white, especially in the neighbourhood of the disc and macula. Owing to the opacity of the retina the outlines of the disc, which is abnormally pale, are obscured. At the fovea centralis, where the retina is ex-

Fig 198 —Perivascular changes in the retinal vessels.

tremely thin, the red reflex from the choroid is visible. It appears as a round "cherry-red" spot, presenting a strong contrast to the cloudy white background. The peculiar tint of the spot is due to this contrast. In the majority of cases there is no hæmorrhage, as was once thought, though hæmorrhages here and in the immediate neighbourhood do occur rarely. The contrast sometimes brings into relief minute blood vessels near the macula which are otherwise invisible.

Sometimes the obstruction to the blood flow is not complete, or the flow may be partially restored in the course of a few days. Another peculiar phenomenon may be observed or may be

PLATE XII.
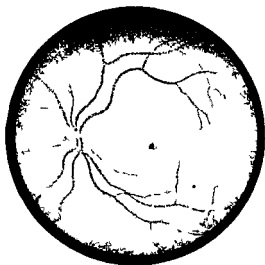
Fig 1 —Embolism of the central artery

Fig 2 —Thrombosis of the central vein

PLATE XIII
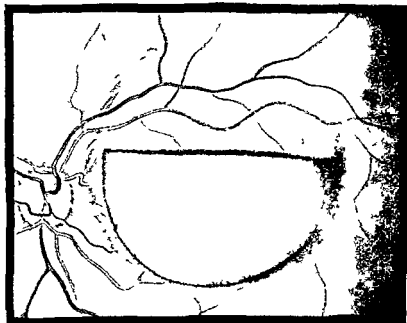
Fig 1 —Subhyaloid hæmorrhage

Fig 2 — Petinitis proliferans

induced by gentle pressure upon the globe In some of the vessels, usually veins, the column of blood is broken up into red beads separated by clear interspaces The beads move in a jerky fashion through the vessels, sometimes in the normal direction of blood flow, sometimes in the opposite direction. If the veins are easily emptied of blood or arterial pulsation is

Fig 199 —Obstruction of the Central Artery (Coats) Showing central vessels posterior to lamina cribrosa The artery, to the left is collapsed and obliterated by proliferation of endothelium The vein is concentrically narrowed by thickening of its walls not by endothelial proliferation

produced by slight pressure on the eye ball, it is evidence of incomplete blockage

The retinal œdema, or possibly coagulation necrosis, takes several weeks to clear up The membrane regains its transparency, but is completely atrophic The vessels are contracted or reduced to white threads The disc is atrophic If there have been hæmorrhages spots of degeneration replace them, and cholesterin crystals and pigmented spots may be seen in the papillo macular region

In some cases a certain degree of central vision persists in spite of apparent complete occlusion of the central artery It is due to the presence of cilio retinal arteries (*vide* p 125),

which, when present always supply the macular region, and
naturally escape occlusion, or to a macular branch of the
central artery given off proximal to the block   The remainder
of the field of vision is lost   In rare cases a cilio retinal artery
alone becomes blocked

After the first stage, in which the arteries are threadlike
from sudden partial or complete arrest of blood flow, the
vessels refill slightly, showing a small stream in more or less
normal arteries   This is due to establishment of a feeble col
lateral circulation through the anastomoses with the ciliary

Fig 200 —Retinal vein with enormously thickened wall and narrow
lumen (Coats)   The perivascular lymph space is dilated

system round the disc (*vide* p 11)   At a later stage the vessel
walls become thickened so that the thin red line is bordered
by white lines, the last stage of threadlike sclerosed arteries
The final stage of complete obstruction of the central artery
shows a pale atrophic disc due to degeneration of the nerve
fibres of the retina and disappearance of the capillaries of the
nerve head   threadlike retinal arteries containing blood only
on and near the disc, and larger veins containing blood   the
rest of the fundus is of normal colour and appearance   Unusual
freedom of collateral circulation may account for the consider
able recovery of vision which occurs in rare instances, almost

invariably limited to the temporal field In rare cases, too, visible anastomoses have been seen on and at the edge of the disc

It might be thought that the intraocular pressure would force the blood out of the veins , but there is normally some obstruction to the outflow at the lamina cribrosa, where the venous pressure is lowest This is shown by the occurrence of venous pulsation (*vide* p 126) The blood is dammed back by the constriction of the elastic fibres of the lamina cribrosa

In other cases the embolus is arrested in a branch of the central artery The area supplied by this branch is then affected alone In the early stages the corresponding scotoma is usually some what indefinite but later it settles down to a permanent sector shaped defect

When perception of light is lost the pupil is large and the direct reaction to light fails The intraocular tension is normal, as might be anticipated

There is occasionally the history of prodromal attacks of temporary obscuration of vision Some are due to local arterial disease associated with temporary diminished blood pressure, and arterial spasm may play a part

Embolism of the central artery, like cerebral embolism, occurs with mitral stenosis, especially if there has been fresh endocarditis This factor is, however, very frequently absent, and it is probable that most cases are really due to thrombosis There has been endarteritis due to general arteriosclerosis from nephritis &c , and the already narrowed lumen of the vessels has become suddenly occluded The onset may be less rapid in such cases and preceded by premonitory symptoms, such as obscuration of vision, &c   Other cases render it probable that the condition may be due simply to spasm of the walls of the artery, thus accounting for some remarkable cures In others it may be that an embolus has been forced on into a smaller, more peripheral branch

The condition has been observed at ages varying from fifteen to eighty Rare cases of simultaneous bilateral blocking of the central arteries have been recorded

The blockage, whether due to embolus or thrombosis, is nearly always at the lamina cribrosa where the vessels normally become slightly narrowed (Fig 199) The retina undergoes atrophy of the nerve fibre and ganglion cell layers, with preservation of the outer layers, which receive their nourishment from the chorio capillaris of the choroid

Treatment is seldom of any avail, but attempts should be made to drive the obstruction on into a less important branch if the case is seen early. Massage of the globe, and paracentesis have been employed for this purpose, such measures must be adopted without delay. Inhalation of amyl nitrite is useless— as might be expected—since it lowers the general blood pressure and leads to passive constriction of the intraocular vessels. A definite case of cure of embolism of a branch of the central artery by the subconjunctival injection of acetyl choline has been reported (Orr and Young). 8 minims (B D H) should be injected into Tenon's capsule and behind the equator. The drug causes great dilatation of both arteries and veins in the retina, the embolus being driven on into a smaller and more peripheral branch.

Amaurotic Family Idiocy (*Syn —Tay Sachs Disease*) shows ophthalmoscopic signs resembling those of embolism of the central artery but of quite different origin. The disease occurs almost if not quite invariably in Jewish children, and commences during the first year of life. Several members of a family may be affected. The apparently healthy child becomes gradually blind, with muscular weakness and wasting, and mental apathy passing into idiocy. Death follows in from one to two years. The opthalmoscopic picture is very characteristic and the same in every case. There is a round brilliantly white area at the macula fading off peripherally into the normal fundus. In the centre of the patch is a brownish red circular spot at the fovea. In the later stages there is optic atrophy. It is always bilateral. The disease is a primary lipoid neuronic degeneration of the whole of the central nervous system, including the ganglion cells of the retina associated with profuse overgrowth of neuroglia.

Maculo-cerebral Family Degeneration has some points of resemblance to amaurotic family idiocy, and has been regarded as a delayed or juvenile form of the disease but should be carefully distinguished from it. It is a familial disease, occurring in other than Jewish children, and commencing at a later age usually at about six or eight years. It is relatively commoner in Sweden (Sjögren). Defective vision, with central scotoma, is accompanied by weak intellect, convulsions and spasticity. Ophthalmoscopically the discs are pale and the vessels small. At the macula there are yellowish grey spots and granular pigmentation, and there may be pigmentation in other parts of the retina. The ophthalmoscopic picture varies much in different cases. Similar macular degeneration beginning between the ages of twelve and fourteen has been

seen as a familial disease without cerebral deterioration (*Stargardt's Disease*)

Degenerative Changes in the Retinal Vessels, apart from their interest as a local manifestation of disease, are of the utmost importance in general prognosis They may be the first evidence of arteriosclerosis, and particularly of disease of the cerebral vessels, pointing to the danger of cerebral hæmorrhage, and indicating lines of treatment which may prolong life Disease of the retinal vessels is almost invariably associated with disease of the cerebral vessels, but disease of the latter may be present when there are no ophthalmoscopic signs of disease of the retinal vessels (Foster Moore) Undue tor-
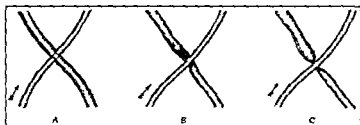
Fig 201 —Retinal vein crossed by an artery (Marcus Gunn) A In health, the underlying vein dimly traceable beneath the artery B In early stage of arteriosclerosis the vein somewhat displaced in the direction of the arterial circulation, and its blood flow slightly obstructed C In advanced stage of arteriosclerosis the vein greatly narrowed where crossed and distended on the peripheral side

tuosity of the vessels is of no significance unless accompanied by other abnormalities, such as irregularity in the size and breadth of the arteries, so that stretches of the vessel are much constricted, alternating with normal or somewhat dilated portions These changes in the lumen are due to endothelial proliferation in the intima Minute miliary aneurisms are seen in rare cases The normal light reflex from the vessel walls is often unusually bright and broad, especially in vessels at some distance from the disc ("copper-wire" arteries) (Fig. 197). Under normal conditions it is possible to see a vein through an artery at a point of crossing , in arteriosclerosis the artery loses its translucency so that the vein is obscured Moreover, the artery exerts an abnormal pressure on the veins so that the blood flow is obstructed , the vein seems therefore to stop at

the crossing and is more distended on the distal side than on the side towards the disc (Fig 201) Sometimes the vein appears to be pushed aside by the crossing artery, in severe cases the vein, whether crossing above or below the artery, is diverted so that it crosses at right angles, the shortest possible route The veins may also exhibit a beaded appearance, with alternate constrictions and dilatations More pronounced changes make the walls of the vessels visible, so that the blood column, often narrowed, is bounded by white lines, the thickened fibrous walls (Fig 198) this may affect both arteries and veins, usually only individual vessels in a portion of their course (Figs 197 198)

The changes indicated lead to increased permeability of the walls, and increased internal pressure, due to general disease, supplements this defect, and causes undue extravasation of lymph, and even hæmorrhage Œdema of the retina thus arises, manifesting itself as a greyish opacity around the disc, or in spots along the course of the vessels Hæmorrhages occur as linear striated extravasations along the vessels, or as round spots scattered over the fundus

These changes occur most frequently in elderly people and are seldom entirely absent in the aged They are specially pronounced in cases of chronic nephritis, syphilis, some forms of poisoning, especially by lead and probably by auto intoxication, notably that of intestinal origin They are frequently associated with high blood pressure, and always indicate the necessity for exhaustive examination of the circulatory and excretory systems On the other hand, the blood pressure may be normal, possibly owing to cardiac dilatation, and these cases are probably more subject to thrombosis (Foster Moore) The prognosis as regards life in retinal vascular disease is decidedly better than in cases of renal retinitis (q v), though the patients may die suddenly from cerebral hæmorrhage or thrombosis Vascular changes are more frequent in women than men, though the former seem to be more tolerant of high blood pressure than the latter (Foster Moore) They may be very marked and extensive in quite young people as the result of congenital syphilis, rarely as an hereditary condition without syphilitic taint Extensive disease of the retinal vessels, with much diminution in their calibre, so interferes with the nutrition of the retina that consecutive atrophy of the optic nerve not infrequently follows The ophthalmoscopic appearances of the vessels and disc then closely resemble those found in advanced cases of retinitis pigmentosa This condition may

be accompanied by groups of sharply defined small white spots in the retina and even a fan or star shaped figure at the macula (Foster Moore) (*arteriosclerotic retinitis*) It is frequently unilateral thus differing from renal retinitis

Angioid Streaks Dark brown or pigmented streaks, which anastomose with each other and resemble blood vessels in distribution, are sometimes seen ophthalmoscopically in retinæ which are undergoing degenerative changes They differ in distribution from any normal set of vessels, are usually situated near the disc at a deeper level than the retinal vessels and are very irregular in contour They are often associated with elastic pseudoxanthoma of the skin They may be due to proliferation of new vessels into scar tissues (W T Lister), or to pigmented fibrous bands in the inner layers of the choroid (Verhoeff), but are probably due to changes in the elastic tissue of Bruch's membrane

Hyperæmia may be arterial or venous Arterial hyperæmia, characterised by fulness and tortuosity of the arteries accompanies not only inflammation of the retina, but also inflammation of neighbouring structures especially the uveal tract Venous hyperæmia characterised by dilatation and great tortuosity of the veins, is the result of impeded return of blood to the heart It may be due to general venous congestion, seen in its most extreme form in congenital malformation of the heart (*cyanosis retinæ*), or to local causes The latter most commonly affect the veins in the porus opticus, as is seen in moderate degree in glaucoma and optic neuritis, and in extreme form in thrombosis of the central vein of the retina Increased intraorbital pressure, as from a tumour may also impede the exit of blood from the eye The veins are much enlarged and dark in colour in polycythæmia

Hæmorrhages from the retinal vessels may be pre-retinal or intra retinal *Pre-retinal or subhyaloid hæmorrhages* are extravasations of blood between the retina and the vitreous They always occur in the neighbourhood of the macula, and are usually large They are round at first, but quickly become hemispherical, the upper margin being straight, this is due to the effect of gravity (Plate XIII, Fig 1) Occasionally two such hæmorrhages may be seen in the same eye Retinal vessels are hidden from view in the affected area The upper layers become lighter in colour, generally attributed to the sinking of the red corpuscles The blood gradually becomes absorbed, usually in a patchy manner, but finally disappears, though numerous cholesterin crystals may often be left as bright glistening spots Vision is restored, but recurrences are

not uncommon and other complications of vascular origin may modify the otherwise favourable prognosis. They are for example not uncommon in cases of subarachnoid hæmorrhage (*vide* p 607)

Intra retinal hæmorrhages as already mentioned are striate

Fig 202 Thrombosis of a branch of the central retinal vein

or flame shaped when situated in the nerve fibre layer rounded or irregular when in the deeper layers or between the retina and choroid. Intra retinal hæmorrhages are absorbed very slowly gradually becoming white rarely pigmented

Retinal hæmorrhages are due to many causes. Most frequently the vessel walls are weakened by general disease which may be a vascular degeneration due to age or to altered

composition of the blood as in pernicious anæmia, leucæmia, scurvy, purpura, nephritis, diabetes, hyperemesis gravidarum (*vide* p 592) &c   Any of the causes leading to retinal hyper-æmia may give rise, secondarily, to hæmorrhages   They may be due to pressure during birth in new born infants, and are
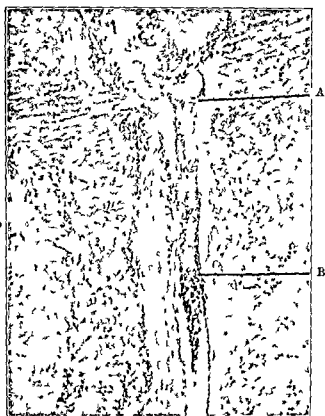
Fig 203—Thrombosis of central vein (Coats) Longitudinal section of nerve From the region of the lamina cribrosa A, backwards the vein is occupied by a homogeneous coagulum there is slight endothelial prol feration At B the coagulum is invaded by cells polymorphonuclear leucocytes and larger paler cells

probably responsible for some so called congenital retinal defects, *e g*, white and pigmented spots of atrophy at the macula and elsewhere   Similarly they occur in cases of severe compression of the thorax or neck in older people   Whooping cough may lead to retinal as well as the more common con-junctival hæmorrhages   Traumatism *e g*, severe contusions

and wounds, gunshot wounds of the eye, and of the orbit without direct injury to the eye, is another cause, and is often responsible for very extensive extravasations of blood, which may burst through into the vitreous To this category belong the post-operative hæmorrhages When the globe is opened in performing cataract extraction, or, still more irridectomy for glaucoma, the normal or raised intraocular tension is suddenly reduced to zero The intraocular vessels then dilate, and great strain is thrown upon their walls If these are diseased, there is much danger of their rupturing Considering the age and condition of these patients, it is surprising that hæmorrhage is not more frequent

Minute hæmorrhages, unless in the macular region may cause little obscuration of vision Subhyaloid hæmorrhage usually abolishes central vision temporarily it takes some weeks to clear up, the length of time varying with the size of the extravasation The smaller spots may remain unaltered for months though this is only apparent in some cases old spots clearing up and being replaced by new ones They may be absorbed without leaving any trace

Venous Thrombosis may affect the central vein of the retina (Plate XII , Fig 2) or one of its branches (Fig 203) In the former case the obstruction is always just behind the lamina cribrosa (Fig 203) All the veins of the retina become enormously engorged with blood, and extremely tortuous Blood escapes from the capillaries at innumerable spots, so that the retina is covered with hæmorrhages Sight is much impaired, though not so rapidly as in obstruction of the central artery, but recurrent extravasations finally destroy it entirely In the early stages there is constriction of the field of vision and usually a central scotoma When a single branch is blocked the œdema and hæmorrhages are limited to the area supplied by the vein, the block is usually at a bifurcation or where a sclerosed artery crosses the vein In these cases the defect in vision is not sectorial, as in the case of a branch of the artery , it is worse if the temporal branches are involved, and unfortunately it is the superior temporal vein which is most often blocked The affected retina becomes atrophic, with fine pigmentary changes Secondary glaucoma ensues in two to three months in a considerable number of the cases, probably owing to the increased albuminous constituents of the intraocular lymph It does not occur when only a tributary is involved In many cases bunches of tortuous new vessels are formed upon the disc

(Fig 204), in others a collateral circulation is effected by similar tortuous new vessels in the retina Such vessels often project forwards into the vitreous, and may rupture, leading to extensive vitreous hæmorrhages Vascular disease and hæmorrhages are not infrequently present in the other eye, and bilateral thrombosis of the central vein sometimes occurs In all cases examined microscopically the vessel walls are diseased and show endothelial proliferation The lumen is constricted, and it is probable that this factor is as important in causing obstruction as actual thrombosis
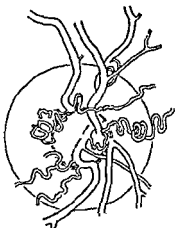
Fig 204 —New formed vessels. (Foster Moore)

The patients are usually elderly, with cardiac or vascular disease, often induced by nephritis , the blood pressure is usually high, and there is often albuminuria Women are affected more often than men The obscuration of vision is almost always noticed on waking in the morning Probably the low blood pressure and sluggish flow during sleep allow thrombosis to occur in the vessel where it is constricted normally at the lamina cribrosa and pathologically by endovascular changes Thrombosis may, however, be due to local causes, such as orbital cellulitis, following facial erysipelas, &c It occasionally occurs in young people following a febrile attack, and is then probably due to an infective phlebitis The other eye usually shows vascular disease and often small hæmorrhages in the periphery of the retina Bilateral thrombosis is rare

Treatment No treatment is of avail in cases of complete occlusion Cases of improvement in partial thrombosis by intravenous injections of heparin have been published Atropine should be avoided, as tending to induce glaucoma Local treatment is indicated only if the eye becomes painful, when it should be removed The condition is to be regarded as a danger signal, and constitutional investigation and treatment be carried out assiduously

Special Forms of Retinitis

Syphilitic Retinitis Syphilis is one of the commonest causes of retinitis, but it is usually a secondary retinitis, accompanying

disease of the choroid   It, however, occurs as a primary retinitis also, and in this form syphilitic endarteritis is a prominent sign   There are dust like opacities in the vitreous especially in the posterior part, the retina is cloudy, particularly in the neighbourhood of the disc, which may be hyperæmic   White spots may be seen in the macular region, and yellowish or white spots, often bounded by pigment, at the periphery of the fundus   The vessels may be degenerated (*vide* p 359), with whitish exudations along their course, hæmorrhages are rare

Every transition is seen to a condition much resembling choroido retinitis pigmentosa (*vide* p 347), but seldom showing *such a characteristic distribution of the pigment*

The subjective symptoms are defective central vision, nightblindness, irregular and concentric contraction of the field with or without central, paracentral, or ring scotomata, and metamorphopsia

In most cases the amount of organisation which takes place at the sites of the inflammatory deposits of syphilitic retinitis is very small but in some cases there is a well marked tendency to the formation of new blood vessels   These may not be limited to the retina itself, but may extend into the vitreous, forming convoluted coils   They are held together by a minimum of delicate connective tissue (*cf* Retinitis proliferans) They are commonest in or near the disc

In acquired syphilis the disease usually occurs one to two years after infection, usually both eyes are involved, but not *with simultaneous onset   As a rare manifestation the macular area is alone affected* showing a grey or yellow deposit, or numerous small yellow spots and dots of pigment   This form shows a great tendency to relapse

Retinitis is not uncommon in congenital syphilis   Such patients often show a dusty or peppery discrete pigmentation of the retina at the periphery, associated with a tigroid condition of the fundus in this situation   It is only distinguishable from what is often seen as a normal condition by the greater aggregation of the pigment   There may be thickly strewn black and white spots, like a mixture of pepper and salt   In more definite forms there are yellowish red and black spots at the periphery (anterior retinitis) a condition often seen in interstitial keratitis (*vide* p 237) or larger grey or white patches may be seen, or the condition observed in the acquired form may be fully developed

If the diagnosis is doubtful the Wassermann test should be applied,

Treatment   A prolonged course of anti syphilitic treatment is indicated   Dark glasses should be worn and the eyes rested   Renal Neuro retinitis (Syns —*Renal Retinopathy, Albuminuric Retinitis*) in its most typical form, presents an ophthalmoscopic picture which is almost pathognomonic, being simulated only in some cases of intracranial tumour (Plate XIV) In addition to the general signs of retinitis—haziness of the retina and disc hyperæmia and hæmorrhages—the distinguishing feature is the presence of brilliant white spots and patches in the retina   The earlier deposits are cloudy, with soft edges (' cotton wool' patches), the later brighter more sharply defined and punctate   The disc is surrounded by large white patches or by a continuous ' snow bank ' Around the macula are smaller dots or round patches, also silvery white   Radiating from the fovea are spokes of white dots or fine lines forming a star shaped figure which is extremely characteristic   The fovea itself escapes and the star is often incomplete in some direction   The vessels generally show very definite degenerative changes (*vide* p 359)   In some cases, especially in the albuminuric retinitis of pregnancy, a flat detachment of the retina occurs almost certainly due to the retina being raised from the choroid by exudates The detachment is usually bilateral and involves the lower part of the fundus   Unlike most detachments of the retina these frequently disappear, the exudates being absorbed

Renal retinitis by no means always displays the typical picture   Often there is a neuro retinitis which exhibits no characteristic features specially associated with nephritis In these cases there is moderate swelling of the disc— seldom so much as in the choked disc of intracranial disease— more or less widespread œdema and hæmorrhages   Irregularly scattered bright white spots and patches may be present or wanting   *The urine should be examined in every case of retinitis*

The white spots of renal retinitis are chiefly composed of exudates which are often fibrinous (Fig 205) later becoming hyaline   They are situated particularly in the outer reticular layer where large vacuoles are filled with fluid fibrinous coagula, or hyaline deposits often associated with large globular macrophages , they may be present in all the layers There is some leucocytic infiltration and peculiar swollen nucleated structures—cytoid bodies—are found in the nerve fibre layer   they are probably varicose nerve fibres   The exudates and necrotic retinal elements undergo fatty degeneration   The peculiar arrangement of the spots in the macula

is not due to any supposed radial distribution of Muller's fibres in this situation, but to fluid which raises the internal limiting membrane and follows the radial course of the nerve fibres as they arch towards the disc   Spread of the œdema to the loose reticular layer, which is very well marked in this situation throws the retina into actual radial folds, the fovea itself remaining unchanged and as it were ' pegged down '   The disc shows the same changes as in papillœdema (*q t*), but less marked   The changes in the blood vessels are those common to vasculitis in other small vessels consisting of endo and peri vasculitis and hyaline degeneration of the walls

Fig   205 —Renal retinitis Masses of fibrinous exudate in the retina

There is no constant relationship between the retinitis and the vascular disease   The vessels may be quite normal *e g* , in some puerperal cases and in the rare cases occurring with acute nephritis   In the cases with chronic interstitial nephritis, *i e* , the great majority, the vessels are much diseased   The retinitis is, therefore not directly due to the vascular disease, but probably to toxins circulating in the blood stream

Renal retinitis occurs in about one third of cases of nephritis and may occur in all forms of nephritis including scarlatinal, puerperal and ' trench '   nephritis, but in by far the greatest number of cases the disease is chronic interstitial nephritis and it is very rare in ordinary acute nephritis   The last mentioned fact accounts for the small quantity or even total absence of albumin in the urine in some cases   Though the degree of retinitis bears no fixed relationship to the nature or severity of the renal mischief, yet in all cases its presence is of grave significance   The retinal changes may be the first evidence of renal disease, hence the extreme importance of their discovery, which is accentuated by the fact that the majority of hospital patients die in from six months to two years.   Under more favourable conditions patients may survive five years or even longer   The prognosis is equally grave in children   The risk to life is much less in the scarlatinal and puerperal cases   In the latter the prognosis is worse the earlier

PLATE XIV

Fig 1 Renal retinitis

Fig 2 Renal neuro retinitis

PLATE XV

e detaclment of the retina (diagrammatic)

the onset of the retinitis, but fortunately it seldom commences before the sixth month of pregnancy The artificial induction of abortion is indicated, and usually has a prompt beneficial effect, vision, however, is usually permanently impaired, the degree depending upon the duration of the retinitis The "cotton wool" patches clear up first, the glistening macular spots more slowly Partial optic atrophy and slight retinal changes, such as white or pigmented spots at the macula, follow The disease does not always occur at the first pregnancy , but may, after one attack, recur at subsequent pregnancies, though by no means always The patient should, however, be warned of the danger The retinal changes in puerperal cases are usually severe, and detachment of the retina occurs more frequently in these than in other cases If pregnancy is not interrupted spontaneously or artificially death (about 15 per cent of cases) or blindness (about 13 per cent) occurs, and the child is usually born dead

Diminution of visual acuity is commonly the only symptom complained of, and, as mentioned, may lead to the discovery of the renal disease Generally the history of severe headaches can be elicited, and the blood pressure is high, usually about 200 mm Hg The condition is almost always bilateral It very rarely causes complete blindness It occurs more often in men than in women, owing to the greater incidence of nephritis in men , in children it is commoner in girls than in boys It is commonest between thirty and sixty years of age, especially in the last decade , but it is probably more frequently associated with the parenchymatous nephritis of children, which is generally syphilitic, than has been hitherto thought (Nettleship)

It is important to note that transient blindness may occur in the course of nephritis, especially associated with uræmia In these cases the retina shows no abnormality, or at most changes which may occur independently of the disease This *uræmic amaurosis* is distinguished in being sudden total blindness whereas the defective vision of albuminuric neuro retinitis is slower in onset and never complete Sight usually returns in one or two days (*vide* p 410)

Diagnosis The typical picture of albuminuric retinitis may be nearly simulated in some cases of increased intracranial pressure, particularly when due to cerebral tumours occurring in children (*vide* p 388) It may occur without any definite signs of nephritis, and somewhat similar appearances are met with in diabetes and leucæmia Rarely a star at

the macula with or without slight papillitis, has been met
with in young persons with anæmia or chlorosis, or without
discoverable cause

The *treatment* of these conditions is purely constitu
tional

Diabetic Retinitis   Retinitis is a relatively rare complication
of diabetes, occurs in the late stages, and in elderly people ,

Fig 206 —Diabetic retinitis

it is not improbable that it is frequently missed owing to the
peripheral position of the lesions, opacities of the lens, &c   It
is generally, but not always, bilateral   Irregularly scattered
small, bright white spots around the macular region are the
commonest manifestation   The snowy patches and stellate
arrangement at the macula are usually absent, but it must
be remembered that albuminuria is a frequent concomitant
of the late stages of diabetes, and all the characteristics of
albuminuric retinitis may occur   The white spots may coalesce

into larger plaques with crenated edges, which indicate their mode of formation Punctate hæmorrhages are freely scattered over the fundus they are more often round and deeply seated than linear and superficial as in renal retinitis The vessels are often normal but a degree of vascular degeneration correlated with the age of the patient is not uncommon it is noticeably less than in albuminuria retinitis The optic disc is generally normal as well as the remainder of the retina

The prognosis depends upon the severity of the constitutional condition , 60 per cent live more than two years Under insulin treatment the retinitis may persist indefinitely, for this treatment appears to have no effect upon it

Diabetic retinitis cannot be due to sugar, di acetic acid or acetone circulating in the blood, since it does not occur in children in whom these products of perverted metabolism are most markedly present The blood pressure is usually high, and the condition has been ascribed to the vascular degeneration (*cf* arteriosclerotic retinitis) and in these cases vitreous hæmorrhage may occur

A peculiar feature sometimes met with in diabetes is *lipæmia* It occurs especially in young patients with marked acidosis, and the prognosis is grave The ophthalmoscopic appearances are then striking the retinal vessels containing fluid which looks like milk The arteries are pale reddish, the veins having a slight violet tint The general fundus has much the normal coloration Lipæmia responds rapidly to insulin treatment

Hæmorrhagic Retinitis is a term loosely applied to those forms of retinitis accompanied by hæmorrhages for hæmorrhages may occur as has already been seen in the absence of all signs of inflammation of the retina

Leucæmic Retinitis When retinitis occurs in the course of leucæmia the ophthalmoscopic appearances are characteristic The fundus is pale and orange-coloured The veins are dilated and tortuous often with white lines along them and are bright red not dark the arteries are small and pale yellowish red Very typical are white spots and patches surrounded by a red rim they consist of leucocytes surrounded by red corpuscles These are present only rarely and are also found in pernicious anæmia They are most common in the periphery of the retina In some cases the ordinary picture of hæmorrhagic retinitis is seen In every doubtful case the blood should be examined

"Retinitis Proliferans" When hæmorrhage occurs into the vitreous the blood clot is usually almost completely absorbed This is probably due to the absence of fibroblasts in the vitreous and their scantiness in the retina, for the retinal connective tissue consists of neuroglia, an epiblastic structure which probably takes no part in fibrous tissue formation   The only mesoblastic tissue in the retina is that forming and surrounding the retinal blood vessels   In some cases, however, *blood clot may organise, giving rise to masses of fibrous tissue in the vitreous, vascularised by newly formed blood vessels derived from the retinal system* (Plate XIII , Fig 2) This condition is known as "retinitis proliferans"   The tissue is most commonly situated near the disc, and the vessels spring from this neighbourhood, probably owing to the fact that there is more mesoblastic tissue here than in other parts of the fundus

There seems to be some special factor necessary to stimulate organisation, and it is found in some general diathesis   In nearly all these cases there is either a history of syphilis or the patient is suffering from nephritis, diabetes, or some other form of toxæmia, the origin of which may be obscure, as in some cases of recurrent hæmorrhage (*vide* p 330)

The amount of fibrous tissue varies from the most delicate strands and films supporting new formed blood vessels—specially common in syphilitic cases (*vide* p 366)—to dense bands and membranes stretching far forwards into the vitreous and hiding the fundus   Most extensive pro liferations are met with in war injuries with rupture of both chorod and retina   The bands are often attached to the retina at their apices, and as the fibrous tissue contracts after formation the retina may be pulled up and detached

Vision is generally greatly impaired and, often lost, usually from detachment of the retina   No treatment is of much avail, but hypodermic injections of fibrolysin may be tried, combined with constitutional régime

Retinitis Circinata   Retinal hæmorrhage may give rise to yet another condition in rare cases, generally elderly women   In retinitis circinata there is a girdle of bright white patches with crenated borders around the macula (Fig 207)   The diameter of the girdle, which is usually an imperfect circle or ellipse or horseshoe shaped, open towards the temporal side, is generally considerably greater than a papilla diameter, and follows the larger macular branches of the superior and inferior temporal vessels   The vessels pass over the spots   The macula shows yellowish white areas, slight

pigmentation and often hæmorrhages   The patches develop
slowly and are usually well advanced before noticed   The disease
is unilateral in about half the cases, exudative retinitis has been
observed in the other eye (Coats)   Central vision is much reduced,
but the field remains full   The patches sometimes disappear
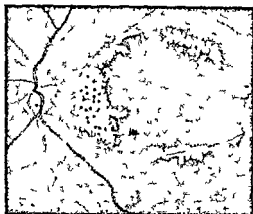
Fig 207 —Retinitis circinata   (Holmes Spicer)

slowly and vision improves   Mercury and iodides seem to afford
the best chance of amelioration

Exudative Retinitis (*Syn —Massive Exudation in the
Retina* (Coats)) resembles conglomerate tubercle in its ophthal
moscopic signs   There is usually a large raised yellowish white
area or several smaller areas posterior to the vessels   The vessels
often show gross degenerative changes, and there is sometimes
arterio venous communication, with enormous dilatation of the
veins   The patients are usually boys, otherwise apparently
healthy   *Detachment of the retina*, cataract or glaucoma may
occur in the late stages   There is always evidence microscopically
of hæmorrhage between the retina and choroid and in the deep
layers of the retina ; the choroid is at first healthy

Angiomatosis of the Retina (*Syn —Angiomatosis Retinæ*, von
Hippel, Lindau) is a rare familial disease which generally becomes
manifest in the third and fourth decades of life, more frequently
in females than males   In its later stages it resembles exudative
retinitis in ophthalmoscopic appearance   The cerebellum,
medulla, spinal cord, kidneys and adrenals are also affected with
angiomatosis and cysts   The ocular lesions are often bilateral,
slowly progressive, and may precede a fatal cerebellar lesion by
ten to fifteen years   The ophthalmoscopic appearances vary

(1) A raised pinkish yellow swelling about 3 m m in diameter, situated between the equator and the ora serrata to and from which run a branch of the central artery and vein, both dilated to three or four times their normal calibre and very tortuous. (2) Multiple crimson glomerulus like tufts at the ends of tortuous arterioles, situated between the optic disc and the equator (3) A mulberry like swelling containing small cysts on the disc and adjacent retina   Retinal and vitreous hæmorrhages and

Fig 208 — Angiomatosis retinæ   (Stallard)

retinal exudates occur later, and detachment of the retina leads to blindness

Treatment   In the early stages the insertion of a katholy is needle into the retinal lesion is effective in destroying it   The area of coagulation around the needle is 0 5 mm , and the number of perforations is assessed according to the size of the mass

Septic Retinitis (Both)   *Apart from endogenous* retinitis (*vide* p 341) metastatic retinitis may manifest itself in the form of small round or oval white spots near the disc, often accompanied by hæmorrhages   This form occurs in puerperal *and other forms* of septicæmia   Usually both eyes are affected

Purulent Retinitis   This is most commonly due to a septic perforating wound being then a precursor of panophthalmitis

(*vide* p 457) Rarely it is a metastatic condition occurring in pyæmia, and probably starting in a septic embolus In the early stages there is severe retinitis with hæmorrhages Suppuration rapidly follows, involving the vitreous, so that a yellow reflex is obtained The condition often passes into panophthalmitis, but less commonly than in cases of exogenous infection Pyogenic organisms are attenuated in the blood stream and tissues, so that the process may subside with the restoration of useful vision (*vide* p 341)

Retinitis from Bright Light, which might be termed *photoretinitis*, occurs after exposure of the unprotected eyes to bright sunlight, as in looking at an eclipse of the sun with unprotected eyes (" eclipse blindness ") or the electric light, as in the intense flash of the short-circuiting of a strong current The relative parts played by the different rays of the spectrum are not fully understood Only a few relatively innocuous ultra violet rays reach the retina On the other hand, practically all the visible rays and many infra red rays pass unimpeded to the retina (*vide* p 22) Much of this radiation is absorbed by the pigment epithelium and it is probable that the pathological changes are produced by the resultant heating effect It is, in fact, a burn of the retina

The symptoms are persistence of the after image, passing on later into a positive scotoma and metamorphopsia Ophthalmoscopically there may be no signs at first, or a pale spot is seen at the fovea with a brownish red ring round it Later there are usually deposits of pigment and small grey punctate spots around the fovea Prognosis must be guarded, since, though improvement often occurs some defect usually remains, and the scotoma may persist permanently

The *treatment* is that of retinitis in general Smoked glasses should be used, or Crookes's glasses, *i e*, such as cut off the ultra violet rays

Toxic Amblyopia Tobacco, alcohol, quinine, filix mas, carbon disulphide, stramonium cannabis indica and other poisons sometimes produce defective vision, which is then known as toxic amblyopia Tobacco and alcohol amblyopias, which are most frequently met with, are usually described as forms of retrobulbar neuritis (*q v*), but experimental and pathological evidence tends to show that the condition is primarily retinal in these cases

Tobacco amblyopia results from the excessive use of tobacco, either by smoking or chewing , and also occasionally from the absorption of dust in tobacco factories Smokers of shag and

strong tobacco mixtures suffer most In most cases there is also over indulgence in alcohol It is known that alcohol alone may produce toxic amblyopia, and cases in which tobacco caused the disease in total abstainers from alcohol have been published indeed the visual loss in these cases is worse than in moderate drinkers The patients may have smoked excessively for years with impunity, the attack coinciding with some intercurrent cause of debility, digestive disturbance, &c They are usually thirty five to fifty years of age

The patient complains of increasing fogginess of vision which is usually least marked in the evening and in a dull light. Central vision is greatly diminished The field of vision is found to be full but there is a central colour scotoma for red and green This is usually small, horizontally oval between the fixation and blind spots, but in rare cases may extend to the limits of the red field, or even be absolute In such cases the possibility of the presence of congenital colour blindness should be borne in mind Both eyes are about equally affected Ophthalmoscopically there may be conges tive haze of the edges of the optic disc followed by undue pallor of the temporal side of the disc, but the changes are usually slight

The course is chronic, and the prognosis is good if the toxic agents are discontinued absolutely The alcoholic cases in non smokers are usually less severe and clear up rapidly Recurrence is very rarely seen Very rarely optic atrophy may result, but it is doubtful if these are uncomplicated cases

The disease is probably due to poisoning of the ganglion cells of the retina In experimental cases, and in one case examined in man, the cells showed vacuolation and breaking up of the Nissl granules This leads to degeneration of the nerve fibres, demonstrable only after they have obtained their medullary sheaths, *i e*, behind the lamina cribrosa The degeneration is found to be limited to the papillo-macular bundle (*vide* p 75) The ganglion cells of the fovea and macular region are the most highly differentiated and are liable to suffer first and most severely in any toxic condition The degeneration is therefore a wedge shaped area on the temporal side of the nerve immediately behind the globe, but becomes a circular central area more posteriorly (Fig 60) This degeneration was discovered early in the history of the disease, and combined with the clinical simi larity to undoubted cases of retrobulbar neuritis led to the conclusion that it was the primary seat of the disease

Nicotine is generally regarded as the toxic agent but it is much more probable that it is one of the more volatile decomposition products of nicotine *e g*, collidine or lutidine

The amblyopia produced by diabetes carbon disulphide and iodoform resembles that of tobacco Diabetics appear to be specially susceptible to tobacco

Treatment consists in total abstinence from tobacco and alcohol It should be combined with tonic treatment especially the administration of strychnine Iodide of potassium may be given and copious draughts of water combined with exercise have been recommended Intravenous injections of vasodilatators such as sodium nitrite (40–50 mgrm) or erythrol tetranitrate (1 5 grain) by the mouth are said to cause rapid improvement and local injections of acetylcholine (*vide* p 358) may also be tried All patients with central scotomata other than those due to total macular degeneration should abstain from tobacco and alcohol

Quinine amblyopia differs in some striking characteristics from tobacco amblyopia Here total blindness (amaurosis) follows the use of the drug even in such small doses as 12 grains in susceptible persons 40 grains is the maximum amount of sulphate of quinine which should be given within twenty four hours (Yarr) The largest doses are usually taken for malaria but quinine is also used as an abortifacient The pupils are dilated and immobile Deafness and tinnitus aurium are present Ophthalmoscopically the retinal vessels are extremely contracted and the disc is very pale œdema of the retina has been described in the early stage In less marked cases or at a later stage the fields of vision are much contracted The fields gradually widen out but do not regain their normal limits Central vision may be completely restored The discs may remain pale for years or become normal Occasionally blindness is permanent and optic atrophy ensues The same condition may follow administration of ethyl hydrocuprein (optochin) for pneumonia and from excessive doses of dial and other barbituric compounds but in the latter cases some vision is regained if the patient survives

Salicylic acid and *salicylates* occasionally produce an amblyopia of the same type and with the same ophthalmoscopic features as that of quinine but *not so severe*

Treatment consists in discontinuing the drug administering amyl nitrite or nitro glycerine supplemented by strychnine and digitalis or local acetylcholine injections

The amblyopias produced by *methyl alcohol, arsenic, lead, nitro-* and *dinitro benzol,* and *filix mas* differ from those of retrobulbar type in the more serious optic atrophy which generally ensues There is probably always a stage at which a central scotoma is present, but it is often missed

Methyl alcohol poisoning from drinking wood-alcohol was common in America during prohibition, and used to occur in England from drinking methylated spirit before it was intentionally adulterated Nausea, headache, giddiness, &c, are followed by coma If the patient survives, vision *very* rapidly fails, passing through the stage of contracted fields and absolute central scotoma to blindness Vision may improve, but usually again relapses, becoming gradually abolished by progressive optic atrophy Rarely restoration is complete Ophthalmoscopically there may be blurring of the edges of the discs and diminished size of the vessels, in the early stages Later there are signs of optic atrophy, usually of the primary type (*vide* p 397)

Arsenic is specially liable to cause optic atrophy, usually total, when administered in the form of trivalent benzol ring compounds such as atoxyl or soamin, arsacetin, hectine, &c These were used for attacking the trypanosome of sleeping sickness, but have now been abandoned The salvarsan group have the arsenic in pentavalent combination and are less toxic no cases of optic atrophy have been reported from their use

Lead poisoning is rarely seen since precautions have been taken to eliminate salts of the metal from pottery glazes, &c The ocular signs are optic neuritis or optic atrophy, which may be primary or post neuritic Some cases have retinitis, which may be due directly to lead or of albuminuric type, secondary to lead nephritis.

Filix mas, used as a helminthetic, may cause amblyopia in excessive doses, especially if given with castor oil The ophthalmoscopic picture is said to resemble that of quinine amblyopia Later, optic atrophy supervenes I have seen a case in which a drachm of extract of male fern was ordered three times a day and was taken for ten days There was total optic atrophy in one eye and partial atrophy with much contraction of the field in the other

Detachment of the Retina (*Syns —Ablatio retinæ, Amotio retinæ*) The retina may become separated from the choroid by being pulled up from within or pushed up from without The simplest example of the former mode is in the late stages of plastic cyclitis when the strands of connective tissue which become attached to the retina contract during the process of organisation The simplest example of the second mode is separation by means of a choroidal hemorrhage, such as may occur from a blow, or disease of the vessels

Clinically detachment of the retina is observed most commonly in three conditions viz, after a blow, in high myopia (60 per cent of cases of detachment), and in sarcoma of the choroid, to these must be added a not inconsiderable number of cases in which no cause can be assigned The exact mechanism of detachment in these cases is by no means completely understood, indeed, detachment of the retina is still one of the difficult problems of pathology It is commonest in men between forty five and sixty five years of age

The patient usually complains that there is a cloud in front of one eye, so that parts of objects, usually the upper or lower parts, are not seen In other words there is a positive scotoma, as is confirmed by making a chart of the field of vision Usually the scotoma corresponding to the detached area is absolute, but in shallow detachments some vision may persist, sufficient nourishment being afforded to the retina from the subretinal fluid There is then generally a relative scotoma for colours, and acquired colour blindness of the tritanopic type (*vide* p 415) is not uncommon It is well to take the field under high and low illumination, the increase in the size of the scotoma in the latter case showing that a larger area of the retina is involved than that which is completely blind As a rule central vision is intact at first, but all detachments of the retina tend in time to be complete when the macular region becomes affected central vision is lost, and when the detachment is total perception of light is lost The first symptom observed sometimes is transient flashes of light (photopsiæ), due to slight displacements of the retina which irritate the neuro epithelium They should always be regarded with serious attention, but not infrequently occur, especially in myopic eyes, without being followed by detachment

A small detachment causes much less definite signs Some obscuration of vision is noticed, but the diagnosis can only be arrived at by careful examination of the fundus and of the field of vision In sarcoma of the choroid the detachment may be very small and in any position, thus differing from the other forms—so called *simple detachment*—in which it is generally larger, though often shallow, and confined to the lower parts of the fundus Simple detachment often begins in the upper part of the fundus, but after a variable time the subretinal fluid gravitates to the lower part of the eye and the retina becomes replaced in the upper part Sarcoma of the choroid may start in the neighbourhood of the macula, and in this case central vision is early affected, as shown by

distortion of objects (metamorphopsia, micropsia, &c) or a relative scotoma for colours   A small detachment due to a sarcoma of the choroid may be accompanied by a large simple detachment in the usual situation above.

Externally the eye looks normal, the anterior chamber may be deep and the tension diminished, though rarely much in the early stages   In cases due to sarcoma of the choroid the tension is always raised in the later stages and the anterior chamber is shallow, occasionally the tension is raised early in these cases

It is by no means difficult to miss diagnosing a detachment of the retina even when it is large, especially if it is also shallow   The symptoms may be indefinite, for the retina may obtain sufficient nourishment from the fluid which underlies it to retain its functions only partially impaired for a considerable period   Failure in diagnosis is almost always due to the omission of a proper routine examination of the eye   The observer often employs the direct method, possibly after a casual examination by the indirect, without previously examining with the mirror alone   A shallow detachment will then appear little altered from the normal fundus   It is true that it is more hypermetropic, but the observer does not realise that he is exercising rather more accommodation in looking at it than at the rest of the fundus   Now, if the eye is examined with the mirror alone at ordinary reading distance, although perhaps no details of the retina are seen—and they will only be seen if the retina bulges far away from the choroid—yet some difference in the nature of the reflex as the eye is turned in various directions will at once arrest attention

Further examination by the direct method will then show the following changes (Plate XV)   The detached portion of retina has a different tint from the normal fundus   In the most typical condition it is quite white or grey, with folds which show a bright sheen at the summits and appear greenish grey in the depressions   During slight movements of the eye the folds show oscillations   The retinal vessels are seen coursing over the surface   They naturally follow all the curves of the folds   Very striking is their abnormal colour   Owing *to the fact that they are separated from the choroid,* which is responsible for the red reflex of the normal fundus, they are under much the same conditions as an ordinary vitreous opacity, *i e* , they cut off the light reflected from the choroid   They therefore look much darker than usual, and may be almost black   They show no central light streak and appear smaller than normal

It now this portion of the fundus is observed with the highest convex glass with which it can be seen plainly, it will be found that the rest of the fundus is out of focus ; this proves that it is displaced forwards and must therefore be detached from the choroid.

In the early stages, and sometimes for a long period in shallow detachments, the colour differs little from the normal. Such cases are much less easy to diagnose, and may give rise to great difficulty, especially if the apparent detachment is very peripheral, for the periphery even of the emmetropic eye is usually seen best with a low convex glass

Fig. 209. — Diagrammatic sagittal section of eye with partial simple detachment of the retina (Nettleship.)

When the detachment is very extensive great balloon-like folds may be seen, and these will probably cut off all view of the disc. At the edges of the detachment a considerable degree of pigmentary disturbance may be seen. White spots of exudation, hæmorrhages, and greyish-white lines due to retinal folds may be seen on the surface of the detached retina. Not infrequently a hole is visible, through which the bright red choroid can be seen (Figs 210, 211). It is probable that there is a hole in every detached retina, but it is not always

Fig. 210—Round hole

Fig 211—Arrow head rent

Figs 210 and 211.—Holes and the Retina. (Shapland.)

visible ophthalmoscopically The most frequent are horseshow or arrow-head shaped, with a lid-like tongue. These are always peripheral and commonest in the upper parts of the retina. They are attributed to traction by vitreous bands. Round holes are usually less peripheral, and may occur at the

macula   In some, especially traumatic, cases the retina becomes detached at the ora serrata (anterior retinal dialysis, 'disinsertion of the retina') (Fig 212), probably following cystic degeneration, which is quite common in this situation

Fig   212 —Anterior   dialysis
(Shapland)

in old people In these cases there is often a very large aperture through which the choroid can be seen, the edge of the detached retina being sharply defined Dis insertion is commonest in the lower parts of the retina

In total detachment the retina is umbrella shaped, remaining attached at the disc and at the ora serrata Still later it be comes bunched up behind the lens, the part attached to the disc being pulled out into a straight cord In these cases the disturbance to nutrition of the eye leads to the development of a complicated cataract ($q\iota$) so that ophthalmoscopic examination becomes impossible

The description given applies especially to so-called *simple* detachment, *i e*, detachment not due to sarcoma of the choroid   The difference may be slight, but accurate diagnosis is of the utmost importance, since the life of the patient may depend upon it   The chief diagnostic features are given in treating of sarcoma of the choroid, and should be very carefully studied (*vide* p 418)

The space between the retina and choroid is filled with a highly albuminous fluid secreted by the choroid (Fig 209)

The prognosis in simple detachment of the retina, un treated by operation, is unfavourable   The detachment becomes total and complicated cataract and iridocyclitis follow   Spontaneous replacement is rare except in cases of renal retinopathy (*vide* p 367) The results of surgical treat ment are good in about 80 per cent of cases due to trauma with retinal dialysis at the ora serrata in the lower temporal quadrant   In healthy patients whose vitreous, retina and choroid show no disease other than changes at the site of the retinal hole the prognosis is good in about 60 per cent of cases if operated on early The prognosis is bad if the detachment has been present for nine months or more ; when the vitreous, retina and choroid are degenerated ; when there is high

myopia, and always in restless and neurotic patients Detachment recurs in some cases, even if the retina has remained *in situ* as long as one or two years

Detachment in a myopic eye is an indication for extreme care of the other eye, which must be regarded as predisposed to the same accident The patient should be warned against stooping, as in gardening, and lifting heavy weights

Treatment A thorough investigation of the affected eye is made before operation Full dilatation of the pupil is very important in order to reveal a retinal tear at the ora serrata it may be necessary to inject mydriacin (3 minims) under the conjunctiva near the limbus in the lower part of the globe Sometimes such a lesion is rendered visible only by making gentle pressure on the sclera near the ora serrata with a strabismus hook A careful drawing showing the position of retinal holes, pathological lesions retinal vessels and other landmarks is made of the fundus Several examinations should be made with the patient in different postures— sitting, supine, lateral and even prone, of these the supine is most important, since this is the position in which the operation is usually performed Changes in posture may reveal a retinal tear which has hitherto been hidden by a retinal fold Accurate localisation of the retinal tear or holes in relation to the outside of the sclera is essential, it is done by assessing in terms of the clock face the meridian in which the hole lies Its distance from the ora serrata is judged ophthalmoscopically in terms of optic disc diameters (= 1 5 mm) The patient rests in bed two or three days before operation

The operation consists in reflecting a flap of conjunctiva and Tenon's capsule, and if necessary dividing an extraocular muscle over the site of the retinal hole (Fig 213) An application of surface diathermy with a 3 mm diameter blunt terminal is made on the sclera, using a current of 80 milli amperes for seven seconds This causes coagulation in the choroid, which should be confirmed by immediate ophthalmoscopic examination It appears as a white patch of exudate *about 4 mm in diameter Its relationship to the retinal* hole determines the sites of further applications of surface diathermy, each being checked by ophthalmoscopic examination The object is to promote adhesion of the retina and choroid around the hole after the subretinal fluid has been evacuated After satisfactory circumvallation of the hole by surface diathermy perforations of the sclera and choroid are

made by a diathermy needle carrying a current of 40 milli
amperes for three seconds The subretinal fluid seeps out,
and its evacuation is completed by suction Ophthalmoscopic
examination should then show apposition of the retina to the
choroid Both eyes are bandaged, and the head is immobilised
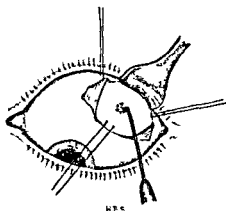
Fig 213 —Perforating diathermy through the site of superficial
diathermy

in a position such that the site of the hole is the most dependent
part

In favourable cases adhesion between retina and choroid is
fairly firm in three or four weeks, but great care must be
taken not to jeopardise its security by undue physical exertion.

Glioma of the Retina   See p 422

Cysts of the Retina are commonly found in the microscopic
examination of degenerated eyes, especially near the ora serrata
in old people . they may lead to holes, disinsertion, and detached
retina Larger cysts occur elsewhere, and are sometimes due to
adhesion of folds of detached retina In rare cases large cysts
may simulate detached retina clinically

CONGENITAL ABNORMALITIES OF THE CHOROID AND RETINA

Coloboma of the Choroid and Retina is a congenital mal-
formation in which the choroid and retina are more or less
badly developed over a certain area, usually the lower part
(typical coloboma) The typical coloboma is due to defective
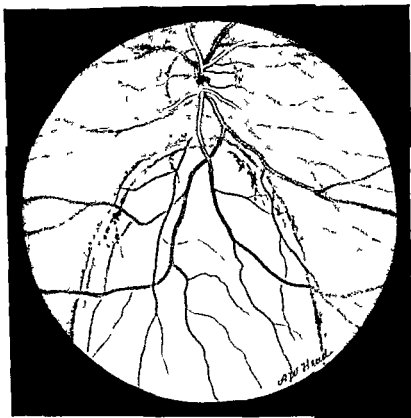
PLATE XVI

Coloboma of the choroid

PLATE XVII
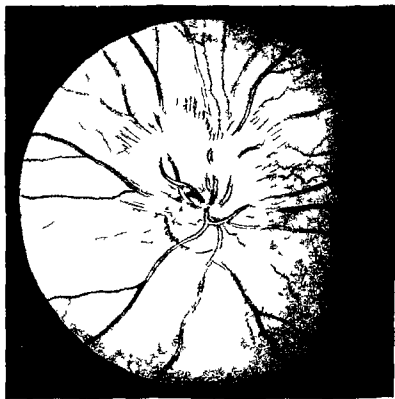
Opaque nerve fibres

closure of the fœtal, so-called choroidal, cleft Ophthalmoscopically there is a glistening white area, usually with patches of pigment at the edges (Plate XVI) There is often also coloboma of the iris (*q v*), and the eye may be small (microphthalmia) The condition is often bilateral, and is frequently hereditary The patch is oval or comet shaped with the rounded apex towards the disc, which may be included or not A few vessels are seen over the surface, some retinal, others derived from the choroid at the edges, but most derived from the posterior ciliaries directly The surface is often depressed irregularly (ectatic coloboma) The central vision is generally bad, and there is a scotoma in the field corresponding more or less accurately with the coloboma, though this usually contains some retinal elements near the edges

Similar patches, often symmetrical in the two eyes, occur in other situations (atypical coloboma), notably at the macula (central or macular coloboma) It is probable that some of these are due to intra uterine inflammation

Albinism is the defective development of pigment throughout the body Owing to absence of pigment in the eye the iris looks pink, and the patients suffer much from dazzling Nystagmus, photophobia, and defective vision—partly due to myopia, or, less frequently, hypermetropia—are present There may be strabismus, usually convergent The condition is hereditary With the ophthalmoscope the retinal and choroidal vessels are seen with great clearness, separated by glistening white spaces where the sclerotic shines through Microscopic examination has shown that total albinism is extremely rare, as traces of pigment have always been found in the retinal epithelium

Partial albinism is commoner, and the absence of pigment is then limited to the choroid and retina, the irides being blue There may be pigment in the macular regions, which may therefore look normal People with dark hair sometimes have relatively slight pigmentation in the periphery of the fundus, so that the choroidal vessels are seen these patients will always be found to have had very fair hair as children

Treatment consists in correction of the refraction by glasses, which should be tinted

Congenital Pigmentation of the Retina Small oval grey spots or groups of polygonal greyish black spots are occasionally met with in the retina in routine examination of the fundus They are flat and lie below the vessels, and remain unchanged indefinitely They are probably congenital and due to heaps of

retinal pigment epithelium similar to those forming melanom ɪ in the ɪrɪs (q v)

Opaque Nerve Fibres The medullary sheaths of the fibre of the optic nerve cease normally at the lamina cribrosa Occasionally patches of fibres regain these sheaths after they have passed through the lamina cribrosa (Fig 214) They appear ophthalmoscopically as white patches, the periphera edges of which are radially striated, looking as if frayed out (Plate XVII) Usually the patches are continuous witl the disc , occasionally they are isolated, but rarely far from

Fɪɢ 214 —Opaque nerve fibres (O), staɪned by the Weɪgert Pal method
R, retina. L, lamina cribrosa. Ꭺ, optic nerve

the disc Usually the retinal vessels are covered ɪn places by the opaque fibres When present the blind spot ɪs en larged, or a scotoma corresponds with the position of the patch Very rarely the patch ɪs large and ɪnvolves the macula so that central vision ɪs abolished If glaucoma or optic atrophy causes the fibres to degenerate the medullary sheaths disappear and no trace of the abnormality remains It ɪs important to be able to diagnose them, since they may be easily mistaken for exudates, e g , albuminuric retɪnɪtɪs They not infrequently occur ɪn both eyes They are not strictly speaking congenital, for myelination of the optɪc nerve progresses from the brain towards the periphery, and *ɪs not completed untɪl shortly after bɪrth*

CHAPTER XVIII

Diseases of the Optic Nerve

THE optic nerve may be attacked by inflammation at any part of its course   The head of the nerve within the globe is frequently affected alone, and this condition is often called optic neuritis or papillitis   When the nerve is affected behind the eye the condition is called retro bulbar or retro ocular neuritis

Hyperæmia of the Optic Disc is a condition which can rarely be diagnosed with certainty   Perfectly normal discs of different individuals show variations in colouring, and slight differences of illumination alter the appearances   There is no doubt that hyperæmia occurs as a precursor of optic neuritis, and in some of these cases it is possible to distinguish greater redness of the disc in one eye than in its fellow under the same conditions of examination

Papillitis (*Intraocular Optic Neuritis*) and Papilloedema. Optic neuritis or papillitis is a term often applied to two groups of cases which should be carefully distinguished, viz., as part of a neuro retinitis (*vide* pp. 352, 367), and as a result of intracranial disease   The pathology of the two conditions is different, though the ophthalmoscopic features may be almost or quite identical   In both there is œdema of the nerve-head, which is associated with true inflammatory changes in papillitis, and is passive in papilloedema   The general features will be considered first, the differences being discussed afterwards

It has already been pointed out that the colour of the disc is a fallacious criterion of abnormality   Attention should be directed especially to the edges, which will always be found blurred, usually first on the nasal side, later in the whole circumference   The blood vessels are altered, the arteries being small, the veins distended   In the early stages the disc is usually redder than normal   In the later stages the blurring of the edges is much greater, and the disc looks larger than usual   Exudates cover the vessels in places, and the veins are greatly distended and very tortuous   The papilla is paler than normal and may be white, it shows radial streaks, and small hæmorrhages are generally present

upon it and the surrounding retina The disc is now quite definitely and measurably swollen (*vide* p 121)

In the papillitis of neuro retinitis the swelling of the disc is usually moderate—2 or 3 D—shelving off gradually into the surrounding retina, which shows the signs of retinitis (*vide* p 351) The disc is redder than normal, owing to dilatation of the capillaries, but the distension and tortuosity of the veins are moderate The "optic neuritis" of intracranial disease may in some cases be a true descending neuritis, and will then show the condition just described, except that there is little or no retinitis The intracranial disease in these cases is usually of an inflammatory nature, *e g*, meningitis More commonly, however, the condition is one of intense œdema with no true inflammation, and this gives rise to papilloedema or "choked disc" (Plate XVIII, Fig 1) Here there is very great swelling—up to 8 or 10 D—usually delimited much more definitely from the surrounding retina, which shows little change The veins are enormously distended and very tortuous, the vessels are hidden in places by white exudates There are frequently hæmorrhages on the swollen papilla and at its edges In many cases it is impossible to distinguish ophthalmoscopically between the two forms The swelling may be unusually great in neuro retinitis, and *per contra* the appearances due to intracranial disease may simulate the neuro retinitis of renal disease, including the star figure at the macula, particularly in children The star figure is rarely complete in these cases, usually it is a fan shaped figure on the disc side of the macula It occurs only in severe cases, and is therefore commonest with cerebellar tumours It may disappear completely after decompression, leaving an apparently normal macula

The symptoms may be extremely vague Central vision may be quite normal, in which case the pupils will also be normal in size and reactions It is very important to remember this fact, which emphasises the necessity of examining the fundus in all cases of headache, &c Even in this stage there may be some concentric contraction of the field of vision Transient attacks of blurred vision, lasting for a few minutes up to an hour or so, are not uncommon in the early stages of papilloedema Visual acuity may be practically unaltered throughout It is usually diminished, but the loss bears no direct relationship to the amount of swelling of the disc Later central vision is reduced, even to complete blindness The pupils will then be large and immobile In less severe cases or

PLATE XVIII.

Fig. 1.—Papilloedema (intracranial disease)
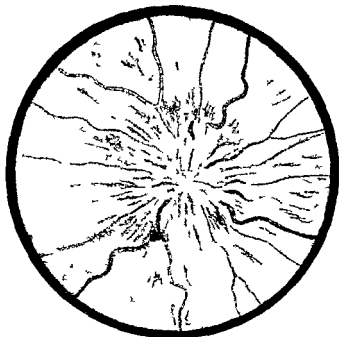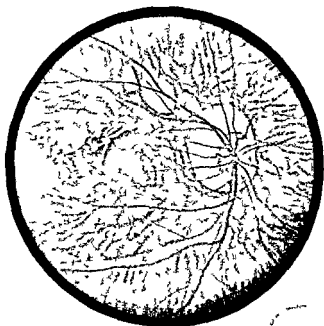
Fig 2.—Myopic fundus changes

[7o

PLATE XIV
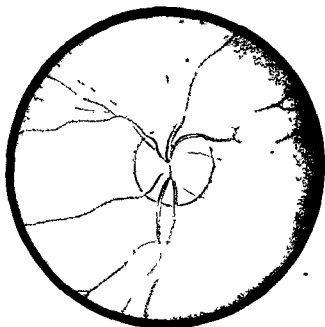
Fig 1 —Primary optic atrophy
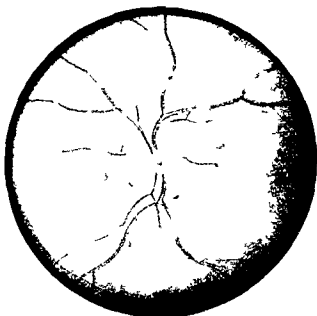
Fig 2 —Postneuritic optic atrophy

in the intermediate stage central vision is defective, the field is markedly reduced concentrically, and relative scotomata—first to green and red—or absolute scotomata may be present There may be hemianopia or other defects in the field dependent upon the site of intracranial lesion When there is extreme loss without much papilloedema it is probably due to the distended third ventricle pressing upon the chiasma and optic tracts It is noteworthy in this relation that the diminution of vision is less with temporo sphenoidal tumours than with those situated elsewhere (Paton) Vision may be normal in spite of a macular fan Premonitory attacks of blurred vision are commonest with cerebellar tumours, possibly owing to interference with the circulation in the occipital lobes Positive subjective phenomena, e g , seeing coloured lights, &c , are rare In the papillitis of neuro-retinitis central vision is always reduced

Both in neuro retinitis and in intracranial disease the condition is generally bilateral, though not necessarily equal on the two sides The relative amount of swelling may be of localising value in the case of intracranial disease, but its value has certainly been over-estimated , in frontal tumours and middle ear disease the swelling is usually greater on the side of the lesion The time of onset of the papilloedema is really more to be taken into account than the amount of swelling, the localising value being attached to the side first affected Thus the swelling may be actually less on the side first affected owing to subsidence associated with commencing atrophy Unilateral papilloedema, with or without " secondary " optic atrophy on the other side, suggests a tumour of the opposite olfactory lobe or orbital surface of the frontal lobe or of the pituitary body (vide p 393) Unilateral papilloedema occurs in the early stages of increased intracranial pressure and in orbital diseases such as tumours of the optic nerve or orbit, cellulitis of the orbit, hæmorrhage into the sheath of the optic nerve &c

The course is chronic, the prognosis bad Occasionally, especially in syphilis, the disease subsides under treatment and good vision is preserved The same applies to cases due to intracranial pressure if the pressure is relieved early Palliative decompression by trephining the skull has a remarkable effect Headache, vomiting and stupor are relieved, vision improves rapidly unless the nerves have been irretrievably damaged, and the papilloedema quickly subsides Rarely the discs regain a normal appearance, but often the nerve fibres are destroyed, " post-neuritic " atrophy (q v) follows, and the patient may become blind

(*vide* p 394)   Recurrence of papillœdema is very rare, but has been recorded

Diagnosis is easy in severe cases, it may be very difficult in slight cases   Here the colour of the disc is no sure guide unless there is undoubted difference between the two eyes   Attention should be directed to the edges of the disc, if these can be seen clearly defined with any lens there is no neuritis, but it does
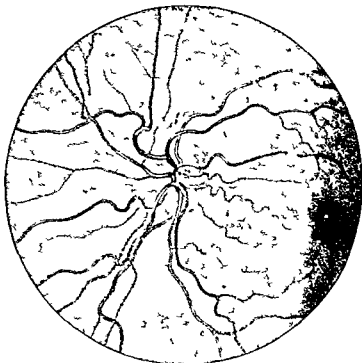
Fig 215 —Pseudo-neuritis

not follow that there is neuritis if they appear blurred   Astigmatism causes apparent blurring of the disc margin and there is a condition nearly simulating slight neuritis known as pseudoneuritis seen particularly in hypermetropic eyes and due largely to a peculiar reflex (Fig 215)   In such cases attention must next be directed to the amount of swelling   In the absence of other indubitable signs such as exudates or hæmorrhages papillitis or papillœdema should not be diagnosed unless at least 2 D of swelling can be demonstrated   In some cases it is

necessary to keep the patient under careful observation for a considerable period before certainty can be arrived at

The following stages may be distinguished in the development of papilloedema (Marcus Gunn de Schweinitz and Holloway) —

(1) Increased redness of the disc, with blurring of its upper and lower margins with a gradual progression of the blurring to the nasal edges, while the temporal margin is still visible, represents the first stage

(2) Increased oedema of the nerve head, beginning filling in of the physiological pit, involvement of the temporal margin of the disc, with a tendency of the oedema to spread into the surrounding retinal area, and uneven distension and darkening of the retinal veins, represent the second stage

(3) Decided increase of oedema, elevation and size of the nerve-head, with vascular striation of the swollen tissue and striæ of oedema in the form of lines in the swollen retina between the disc and macula, marked distension of the retinal veins and retinal hæmorrhages, represent the third stage

(4) Increase in the prominence of the disc, which assumes a mound shape and begins to lose its reddish and juicy colour and to become opaque, exudation in and on the swollen disc and surrounding retina, elaboration of the retinal hæmorrhages in size and number, represent the fourth stage

(5) Decided subsidence of the vascularity of the papilloedema and increasing pallor, with or without sinking of its prominence, apparent contraction of the retinal arteries and thickening of their perivascular lymph sheaths, spots of degeneration of the retina, especially in the macula, represent the fifth stage, which passes into the final stage of so-called post neuritic atrophy

Ætiology The chief causes of papillitis are those of neuro retinitis (*q v*) and of papilloedema intracranial disease   The latter is the more frequent   at least 80 per cent of cases of intracranial tumour give rise to papilloedema   Any intracranial tumour in any position, with the exception of the medulla oblongata, may cause papilloedema, the highest percentage being found with tumours of the mid brain, parieto-occipital region, and cerebellum (*vide* p 605)   The papilloedema is independent of the nature of the tumour and of its rate of growth   The size of the growth is important only in relation to its site   It has been said that papilloedema is less likely to occur in myopic eyes, but this is erroneous   Meningitis is the next commonest cause, especially tuberculous meningitis—basal meningitis relatively rarely   Other intracranial causes are abscess, thrombosis of the cavernous sinus, aneurysm, hydrocephalus (rarely), &c.

Toxæmia accounts for most of the other cases of "optic neuritis" Syphilis may act in this manner as a basal meningitis, or more frequently as an intracranial gumma, it is a frequent cause Papillitis may be due to any of the acute febrile diseases, but only in exceptional cases, and to acute anæmia from sudden loss of blood It occurs sometimes with poisoning with lead and other substances which usually give rise to toxic amblyopia of retro bulbar type (*vide* p 378) It has often been described in chlorosis, and suppression of menses has been given as a cause This ætiology is in my
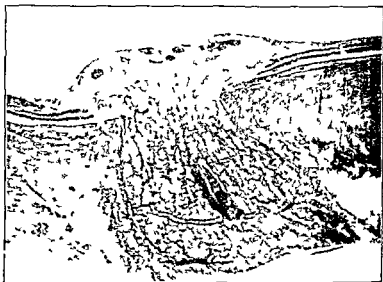
Fig 216 —Papillœdema. (From a photograph by Coats)

opinion doubtful, some cases have subsequently proved to be due to other more serious causes, and many are probably errors of diagnosis (see Pseudo-neuritis, p 390) Slight papillitis has been observed in some of those rare cases in which there is persistent escape of cerebrospinal fluid from the nose Malformation of the cranium, *e g*, acrocephaly, intra-orbital tumours and inflammations—caries, periostitis, &c —and tumours of the optic nerve act directly upon the nerve

Pathology In neuro retinitis there is true inflammation of the nerve, but even then œdema plays a prominent part owing to the obstruction to the outflow of venous blood at the site of the lamina cribrosa (*vide* p 126). Most cases of "choked

disc " are at first caused by simple œdema without inflamma
tion , in the later stages there may be some inflammatory
reaction—infiltration with leucocytes, &c —due to the irrita
tion of the necrosed tissues The œdema occurs first on the
lamina cribrosa and peripheral parts of the nerve , the physio
logical cup then becomes filled in and the internal limiting
membrane raised (Fig 216) The macular fan is caused by
œdema in the nerve fibre layer and raising of the internal
limiting membrane in folds, the outer reticular layer may be
œdematous, but there are no large cystic spaces as in albu
minuric retinitis There is often sub pial œdema distal to the
site of entry of the central vessels into the nerve, but the nerve
is normal proximal to this point It is noteworthy that the
central vein is collapsed where it crosses the sub dural and
sub arachnoid spaces (*vide infra*) In many cases the sub
arachnoid space is so distended that it is ampulliform just
behind the globe The nerve fibres become swollen and
varicose, ultimately degenerating , they show cell like bodies
(cytoid bodies) as in albuminuric retinitis , these are not found
behind the lamina cribrosa The neuroglia proliferates and
the mesoblastic tissue around the vessels becomes thickened
In a minority of cases due to intracranial disease, especially
meningitis, there may be a descending neuritis, with true
inflammation of the nerve

The mechanism whereby œdema is induced by intracranial
disease has been the subject of much dispute and is still an
unsolved problem There is no doubt that the predominant
factor is increased intracranial pressure This is proved by the
fact that the œdema almost invariably subsides, even though
the intracranial disease continues, if the pressure is relieved by
freely opening the skull If communication is cut off from one
intravaginal space by pressure of a tumour of the pituitary
body or olfactory region papillœdema does not occur on this
side, but the optic nerve passes into a condition of partial or
complete " secondary " atrophy (*vide* p 399) The following
theories have been advanced to account for papillœdema
(1) that it is purely inflammatory , this is negatived by the
histological findings, (2) disturbance of vaso motor innerva
tion   there is no evidence in favour of this view , (3)
arterial anæmia, leading to altered conditions of osmosis at
the nerve head , (4) lymph stasis, owing to impediment to
return of lymph *via* the intravaginal space , (5) propulsion of
cerebro spinal fluid through the lamina cribrosa , (6) compres
sion of blood vessels and local vascular engorgement either in

the lamina cribrosa and nerve or in the vaginal space   It is
most probable that papillœdema is due to compression of the
central vessels as they cross the vaginal space, causing collapse
of the vein, whilst the thicker walled artery continues to
transmit blood

The *treatment* of papillœdema is essentially that of the under
lying cause   Local treatment is of no avail, but all sources of
irritation such as bright light, &c , should be guarded against
Intracranial pressure should be relieved before vision is lost, even
if the cause is a tumour which cannot be completely extirpated

If the localising symptoms are positive trephining should be
performed over the site of the tumour if possible   If this is
impossible or if localising signs are masked by pressure symp-
toms a free opening should be made in the skull supra or sub
tentorially according to the indications in the case   The relief
of pressure will alleviate the cerebral œdema and unmask the
localising signs so that it may be possible at a later stage to
undertake a radical operation   Paralysis of the external recti
is often due to the pressure on the sixth nerves in their long
intracranial course, and in
these cases is of no localising
value (*vide* p 561)

If decompression is done
early the prognosis as to sight
is very favourable   After
decompression vision usually
improves rapidly, but only
if the intracranial pressure
is effectually relieved   It

Fig 217 —Diagrammatic meridional
section of optic disc in papillœdema

Retrobulbar Neuritis   The intra orbital portion of the optic nerve may become inflamed as the result of extension from the surrounding tissues   Retrobulbar neuritis is usually divided into an acute, so-called symptomatic form, and a chronic, idiopathic form   The latter is the condition which we have described as toxic amblyopia and have attributed to a primary retinal lesion

. *Acute retrobulbar neuritis is usually unilateral*   The patient complains of sudden obscuration of vision, which increases rapidly during one to eight days, there is sometimes pain on moving the eye   The pain is increased by pressure upon the globe, and neuralgia and headache may be present   Ophthalmoscopic examination will probably reveal a quite normal fundus   It is therefore very easy to overlook the true condition and to attribute the symptoms to hysteria   Careful methodical examination will minimise this danger   Diagnosis at this stage will depend upon thorough investigation of the pupil reactions and of the field of vision   The patient should be asked if he ever squinted (*vide* p 410)

At first glance the pupil reactions will be apparently normal, both directly and consensually to light as well as to accommodation   More minute inspection will show, however, that though the pupil of the affected eye reacts to light the contraction is not maintained under the bright illumination, *i e* instead of remaining contracted the pupil slowly dilates while the light is still kept from the eye   *Lack of sustained constriction of the pupil to light*, if it can be placed beyond dispute, *is of the greatest diagnostic significance*

The field of vision shows a central scotoma which may be relative for colours or absolute. It is not always quite central, but may be paracentral or sectorial or in the form of a ring around the fixation point   There is usually some peripheral loss of the field and there may be complete blindness

In the later stages or more severe cases there are usually ophthalmoscopic changes   These are distension of the veins, with diminished calibre of the arteries, or actual papillitis, moderate in degree   They are most likely to occur if the focus is close behind the eyeball   With or without these preliminary changes atrophy of the optic disc may ensue   In every case in which the inflammation in the nerve behind the globe is so great as to lead to destruction of the nerve fibres in this situation the degeneration extends not only towards the brain but also towards the eye   In the milder cases pallor of the disc is limited to the temporal side, corresponding with degenera

the lamina cribrosa and nerve or in the vaginal space It is most probable that papillœdema is due to compression of the central vessels as they cross the vaginal space, causing collapse of the vein, whilst the thicker walled artery continues to transmit blood

The *treatment* of papillœdema is essentially that of the underlying cause Local treatment is of no avail, but all sources of irritation, such as bright light, &c , should be guarded against Intracranial pressure should be relieved before vision is lost, even if the cause is a tumour which cannot be completely extirpated

If the localising symptoms are positive trephining should be performed over the site of the tumour if possible If this is impossible or if localising signs are masked by pressure symptoms a free opening should be made in the skull supra- or sub tentorially according to the indications of the case The relief of pressure will alleviate the cerebral œdema and unmask the localising signs so that it may be possible at a later stage to undertake a radical operation Paralysis of the external recti is often due to the pressure on the sixth nerves in their long

Fig 217 —Diagrammatic meridional section of optic disc in papillœdema

intracranial course, and in these cases is of no localising value (*vide* p 561)

If decompression is done early the prognosis as to sight is very favourable After decompression vision usually improves rapidly, but only if the intracranial pressure is effectually relieved It is not sufficient merely to open the cranium , the dura mater must be incised The recovery of vision may be much more rapid than the subsidence of the papillœdema Vision may deteriorate after operation probably owing to excessive sclerosis and proliferation in the disc If delayed until there is great swelling and exudation, with marked depreciation of vision, and especially if signs of subsidence and commencing atrophy are present, further diminution of vision is to be anticipated Subsidence of the papillœdema is usually rapid after operation, a decided change being seen in a week to a fortnight, though there is considerable variation in dif ferent cases In cerebral abscess there may be temporary increase of the papillitis or swelling after operation without, however, seriously compromising the prognosis

The treatment of papillitis is that of the ætiological factor

Retrobulbar Neuritis   The intra-orbital portion of the optic nerve may become inflamed as the result of extension from the surrounding tissues   Retrobulbar neuritis is usually divided into an acute, so-called symptomatic form, and a chronic, idiopathic form   The latter is the condition which we have described as toxic amblyopia and have attributed to a primary retinal lesion

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tion of the papillo macular fibres It has already been noted that the ganglion cells at the macula are more liable to be affected by deleterious agents than those in other parts of the retina The same fact applies to their axis cylinder processes, contained in the papillo macular bundle, wherever in their course the noxious agent acts This accounts for the clinical similarity between true retrobulbar neuritis and toxic amblyopia

The causes of acute retrobulbar neuritis are local and general Among the former periostitis and transmission of inflammation from the ethmoidal and sphenoidal sinuses may be mentioned, hence attention should be directed to any nasal complication Hæmorrhage into the optic nerve sheath or orbit and fracture of the base of the skull, involving the optic foramen, may produce a similar clinical picture Pressure on the chiasma by hypertrophy or tumour of the pituitary body or tumour of the frontal lobe may in the early stages cause the symptoms of a unilateral retrobulbar neuritis (*vide* p 408, see also hereditary optic neuritis, *infra*) Among general diseases which cause retrobulbar neuritis insular sclerosis is one of the most important, it is a very frequent early symptom in this disease, which should always be suspected, especially when the symptoms occur in young women. Considerable recovery of vision usually occurs (*vide* p 400), but recurrence is not uncommon (*vide* p 595) Other alleged causes are rheumatism, chills, diabetes, infectious diseases, septic foci somewhere in the body (mouth, intestinal tract, &c), and so on. In cases due to such causes relapses are common, and both eyes may be affected, together or alternately Acute retrobulbar neuritis may be preceded by peripheral facial palsy of the same or opposite side, and shows some analogies to this condition (Marcus Gunn) The prognosis depends upon the cause and the possibility of combating it, but is generally good In multiple sclerosis the affection of the nerve never leads to complete blindness (*cf* Tabetic Optic Atrophy, p 400)

Treatment consists in attacking the cause, the mouth and nasal sinuses being specially carefully investigated The eyes must be protected from bright light, and kept at rest by atropine and abandonment of near work When the cause is obscure, mercury, iodides salicylates, diaphoresis, and tonics may be used Intravenous injection of vaso dilators has been advocated (*vide* p 377) Smoking should be prohibited Cases in which disseminated sclerosis is suspected should be referred to a neurologist for further investigation In diabetic cases appropriate régime should be instituted

Hereditary Optic Neuritis (Syns —*Hereditary Optic Atrophy, Leber's Disease*) is a form of retrobulbar neuritis, usually commencing at about the twentieth year of life Descent is generally through an unaffected female to the males, though females are also sometimes affected Vision generally fails rapidly at first, then gradually, then remains stationary or gradually improves Both eyes are always affected, though one may precede the other by a few days up to eighteen months In two thirds of the cases there is a central scotoma, either partial for colours or also for white The peripheral field is usually normal but concentric contraction or sector shaped defects may occur Total and permanent colour blindness has been known to follow The central scotoma generally persists, but progressive constriction of the field to complete blindness is rare Members of the same family often show identical peculiarities in the progress of the cases The fundus is at first normal or there is slight blurring of the edges of the disc In later stages after months optic atrophy ensues, with pallor confined to the temporal side or involving the whole disc Apart from headache, migraine, &c , the general health is good Fisher has suggested that Leber's disease is due to transitory changes in the pituitary body (*vide* p 409), resulting in pressure upon the chiasma and associated with the periods of physiological change in the sexual life If this be true treatment with thyroid and pituitary extracts may be good.

Optic Atrophy is the term usually applied to the condition of the disc when the optic nerve is degenerated It has been pointed out that injury to the nerve fibres in any part of their course from the retina to the external geniculate body leads to degeneration not only on the proximal (cerebral) side—as might be anticipated for afferent fibres—but also on the distal (ocular) side (*vide* p 395) Optic atrophy follows extensive disease of the retina from destruction of the ganglion cells, e g , in ' retinitis ' pigmentosa , it also follows destruction of the nerve in the orbit, as in rupture of the nerve at the optic foramen in fracture of the base of the skull severe retrobulbar neuritis &c The break in continuity of the fibres may be at the disc itself, such as results from the strangulation of the papillitis of neuro retinitis or papilloedema These cases are distinguished as "*post neuritic*" atrophy, owing to special features which they often exhibit Besides these causes there is a well-defined group of cases in which optic atrophy occurs

Fig 218 —D agram matic meridional section of the op tic disc in atro phic cupping Note that the lamina cribrosa is not displaced (cf Fig 183)

without previous evidence of severe local inflammation but
associated with general disease, usually of the central nervous
system, or without discoverable disease   Such cases are
described as *primary atrophy*

The essential ophthalmoscopic features of optic atrophy
in general are alteration in the colour of the disc and changes
in the blood vessels   The disc is always pale but may show
varieties of tint specially associated with various types of
atrophy   The pallor affects the whole disc and must be care-
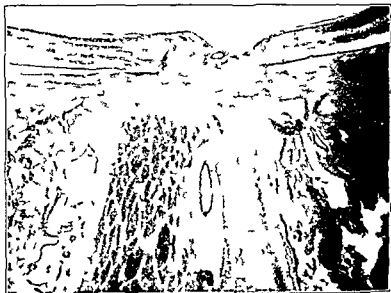
Fig 219—Tabetic Optic Atrophy   (From a photograph by Coats)
The medullary sheaths of the normal nerve fibres are stained black
by the Weigert-Pal method.

fully distinguished from the white centre often encroaching
upon the temporal side, due to physiological cupping   The
pallor is not due to atrophy of the nerve fibres, but to loss of
vascularity , hence it is an uncertain guide to visual capacity
(*vide* p 400)   The change in the vessels is always on the side
of contraction, but may be absent

In primary (grey, tabetic spinal) atrophy the disc is grey
or white sometimes with a greenish or bluish tint (Plate
XIX., Fig 1)   The stippling of the lamina cribrosa is seen , *the*
edges are sharply defined, and the surrounding retina looks
normal   Owing to the degeneration of the nerve-fibres

(Fig 219) there is slight cupping (atrophic cupping) (Fig 218), which must be carefully distinguished from glaucomatous cupping It is shallow and saucer shaped, as shown by the slight bending of the vessels, but is scarcely measurable with the ophthalmoscope There is no retraction of the lamina cribrosa The vessels are normal or only slightly contracted Both eyes are generally affected

In the "secondary" atrophy of retrobulbar mischief the condition nearly resembles primary atrophy, but there is greater pallor, and the vessels are more likely to be contracted In the "consecutive" atrophy of retinal and choroidal disease, as typically represented by the late stages of "retinitis" pigmentosa, the disc has a yellowish wavy appearance, the edges are less sharply defined, and the vessels are very markedly contracted, sometimes to almost complete disappearance This type of atrophy occurs in severe cases of disease of the retinal blood-vessels

Post neuritic atrophy may be indistinguishable from the other forms ophthalmoscopically More commonly it can be diagnosed with considerable probability by characteristic signs (Plate XIX , Fig 2) These depend upon the fact that the absorption of the exudates leads to a certain amount of reactionary organisation, with the formation of a variable quantity of fibrous tissue upon the disc This tissue obscures the lamina cribrosa and fills in the atrophic cup It extends over the edges, which are thus indefinite, and along the vessels as a thickening of the perivascular sheaths Further, it throttles the vessels, so that they become markedly contracted, especially the arteries Owing to previous neuro-retinitis the surrounding retina often shows permanent changes, chiefly manifested by pigmentary disturbance When such changes are well marked previous papillitis may be hypothesised with great probability, but in their absence the conclusion that there has not been papillitis is not justifiable The amount of reactionary organisation varies greatly in different cases, and the tissue laid down is in the course of time gradually absorbed to some extent It must also be remembered that the *amount of fibrous tissue* on the normal disc varies considerably and that slight filling in of the physiological cup with shreds of fibrous tissue extending outwards along the vessels occurs as a congenital peculiarity

In total optic atrophy the pupils are dilated and immobile to light and the patient is blind When unilateral the consensual reaction to light is exaggerated In partial optic

atrophy central vision is depressed and there is concentric contraction of the field, with or without scotomata, relative or absolute, according to the cause   In primary atrophy the disease is usually slowly progressive, ending after months or years in complete blindness   It is important to note that no deduction as to the amount of vision can be made from the ophthalmoscopic appearances   The presence of all the signs of atrophy is not inconsistent with a certain, sometimes considerable, amount of vision

   The chief cause of primary optic atrophy is tabes   It may be the first sign, and the other symptoms and signs may be long delayed   The patient should be carefully investigated for a history of syphilis, the presence of Argyll Robertson pupils, the absence of knee jerks, the presence of anæsthesia (especially of the fifth nerve), inco-ordination, a positive Wassermann reaction, and so on   If optic atrophy occurs early in tabes, ataxy may be long delayed or never supervene   On the other hand, if it occurs late there is no appreciable difference in the course of the ataxy   Both eyes are affected but often in unequal degree   The disease advances slowly but surely to complete blindness—progressive optic atrophy *par excellence*   The lesion was formerly supposed to be in the ganglion cells of the retina, but there is now considerable evidence that the earliest change is an inflammatory exudation into the intracranial part of the nerve and the chiasma   A similar condition may be due to general paralysis and insular sclerosis, less commonly to other forms of central nervous disease, in insular sclerosis the course of the disease is usually different —variations, or repeated acute attacks, never causing complete blindness   The more favourable prognosis in disseminated sclerosis may be due to the fact that in this disease the axis cylinders often escape in spite of much destruction of their medullary sheaths   Primary atrophy may be due to poisons, such as methyl alcohol, lead atoxyl, &c (*vide* p 378)   It occurs rarely after repeated large hæmorrhages from the stomach, uterus or nose in unhealthy subjects   Menstrual defects, cold, arterio-sclerosis, &c, have been ascribed as causes in doubtful cases

   In primary atrophy, though central vision is early affected, there is usually no central scotoma   Cases of tabes in which it is said to have occurred (Fuchs) may possibly be due to over-treatment with arsenical preparations   The field shows progressive concentric contraction, often with marked indentations which are rather more common on the nasal side

Finally, usually in a year or two in tabes, the fixation point is engulfed, though eccentric perception of light may still persist for a while on the temporal side   Contraction of the colour fields precedes that of the field for white, so that there is a stage of acquired colour blindness   The prognosis is very bad

"Secondary" atrophy is caused by compression of the optic nerves, chiasma, or tracts by tumours, aneurysm, distension of the lateral ventricles (hydrocephalus), &c   These tumours, &c, are so situated as to press directly upon the nerve fibres without causing much rise of intracranial pressure, as in the case of tumours of the pituitary body, aneurysm of the internal carotid in the cavernous sinus, &c, or to press directly on the chiasma or optic nerves behind the optic foramen, thus blocking communication with the intravaginal lymph-space, as in the case of tumours of the olfactory lobe and inferior aspect of the frontal lobe   The same type of atrophy may follow rupture of the optic nerve at the foramen, hæmorrhage into the dural sheath, section of the nerve, compression by blood clot, acrocephaly, &c, without previous neuritis   Rupture of the optic nerve is often due to fracture of the base of the skull, and may be bilateral   Vision in the eye and direct reaction of the pupil to light are immediately lost, but pallor of the disc does not supervene until the second or third week later.

The prognosis and treatment of post-neuritic atrophy have been dealt with in discussing papilloedema

Treatment of primary atrophy is that of the cause   For the lesion of the nerve itself mercury, iodides, strychnine, nitroglycerine, the constant current, &c, may be used   Attempts have been made to destroy the spirochætes in the central nervous system in tabetic atrophy by raising the body temperature in various ways, *e g*, by induction of malaria, and also to improve the local vascular supply by cyclodialysis   None of these modes of treatment has had appreciable success

Tumours of the Optic Nerve   See Chap XXXIII

Congenital Abnormalities of the Optic Disc

Coloboma of the Optic Disc   This occurs in two forms, one of which is common, the other rare   The common form is due to incomplete closure of the choroidal fissure, and manifests itself as an *inferior crescent*, much resembling the myopic crescent (*q v*), but situated at the lower edge of the disc (Plate VIII , Fig 1)   It is a crescent, whiter than the

disc itself, situated at the lower border It occurs most commonly in hypermetropic and astigmatic eyes, which are often found to have slightly defective vision in spite of correction of any error of refraction It is often slightly ectatic (conus)

In what is commonly known as *coloboma of the disc* (or nerve sheath) there is greater failure of the fœtal fissure to close The disc then looks very large and the vessels have a very abnormal distribution, appearing only above or irregularly round the edges The apparent disc is really the sclerotic and inner surface of the sheath of the nerve, the nerve itself being usually spread out as a pink horizontal linear band at the upper part The floor of the coloboma is white and measurably depressed, often quite ectatic The eye usually has defective vision

Rarer anomalies allied to coloboma are round " *holes* " in the disc, usually looking grey or black owing to the shadow, and situated in the temporal portion of the disc , and patches of *pigment* due to inclusion of retinal pigment epithelium

Mention has already been made (p 399) of excess of *fibrous tissue on the disc* and extending a short distance along the vessels Sometimes the fibrous tissue takes the form of a delicate semi transparent membrane covering the disc and appearing to be slung from the vessels

CHAPTER XIX

Symptomatic Disturbances of Vision

APART from the disturbances of vision which have been
already considered and have their origin in the eye itself,
there are others dependent upon lesions in the visual nervous
paths   Since they not infrequently closely simulate the dis-
orders due to peripheral causes, or are early evidence of disease,
they lead the patient to consult an ophthalmic surgeon   There
are also visual defects the cause and seat of which are im
perfectly elucidated , though some are probably peripheral in
origin, it will be convenient to consider them here

Hemianopia (*Syns —Hemianopsia, Hemiopia*)   Hemianopia
denotes loss of half of the field of vision   The commonest
clinical form is so called *homonymous hemianopia* in which
the right or left half of the binocular field of vision is lost,
owing to loss of the temporal half of one field and the nasal
half of the other   The condition may be due to a lesion
situated in any part of the visual paths from the occipital lobe
to the chiasma   A focus of disease in this area causes loss
of vision of the corresponding halves of each retina (hence the
designation homonymous), *i e* , loss of the opposite halves of
the visual fields

In most cases of hemianopia the fixation point of each eye
escapes (Fig 220)   This is probably due to two causes—
widespread representation of the foveal region in the occipital
lobe of the same side, owing to spread of the fibres of the
papillo macular bundle and of the corresponding neurones of
the third order , and bilateral representation of each foveal
region in each occipital lobe   On Gordon Holmes and Lister s
view of unilateral representation of the macula (*vide* p 75)
the escape of the fixation point in vascular lesions is attributed
to the fact that the occipital pole is supplied by branches of
the posterior and middle cerebral arteries, and that both of
these arteries are seldom blocked at the same time

Lesions of the external geniculate body cause homonymous
hemianopia , those limited to the pulvinar and superior
colliculus do not   Right hemianopia is much more quickly dis
covered than left, owing to the fact that reading is impossible

Left hemianopia is often discovered by the fact that the
patient does not see food on the left side of the plate.
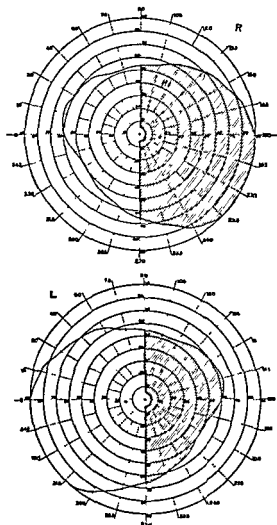
Fig 220 —Charts of fields of vision in homonymous hemianopia.

Cortical and Sub-cortical Lesions. The majority of cases of
hemianopia are due to lesions above the primary visual centres,
usually in the occipital lobe or optic radiations. The injury or
disease rarely affects the grey matter of the occipital cortex
only ; the sub-cortical white matter is almost invariably

involved   The chief causes are injury by falls on the back of the head or gun shot wounds, cerebral tumour, cerebral softening due to syphilitic or other disease of the blood vessels, &c   In gun shot wounds both occipital lobes are not infrequently injured   There is usually unconsciousness from concussion at first, with the gradual recovery the hemianopia becomes manifest   If both lobes are extensively injured there is bilateral hemianopia with complete blindness   Often, however, some portion of the cortex of one or other calcarine fissure escapes, and in these cases some measure of central vision is regained   In less extensive injury the hemianopic symptoms may gradually improve   The first sign of improvement is the perception of the movement of objects in the affected field, the nature and details of the objects being as yet quite unrecognised   The onset of hemianopia due to disease of the cortex is more gradual, and careful investigation with the perimeter shows that the colour fields are often lost before the field for white light, but the field for white is always contracted in these cases (Gordon Holmes)   This *hæmachromatopsia* is itself of gradual onset, the colour fields becoming contracted   In cortical and sub-cortical lesions the pupil reactions are normal (*vide p* 59), and in many cases the fundi reveal no ophthalmoscopic changes   The chief exception to the latter statement is in the case of tumours of the occipital lobe in which case the rise of intracranial pressure leads to bilateral papillœdema   Cortical lesions are liable to be accompanied by word blindness probably due to involvement of the angular gyrus   When the lesion is in the posterior part of the internal capsule hemianæsthesia, with or without hemiplegia, is likely to be present

Rare cases of homonymous *quadrant hemianopa* have been reported, in which corresponding quadrants of each field—the upper or lower half of one temporal, and the upper or lower half of the other nasal—have been lost   These are generally caused by cortical or sub-cortical partial lesions of one occipital lobe, destruction of the part above the calcarine fissure leading to loss of the lower quadrants and *vice versâ*   Figs 63 and 64 show the probable representation of different portions of the field in the visual cortex according to Gordon Holmes and Lister

Homonymous defects in the visual fields are found associated with lesions of the temporal lobe owing to the fact that a ventral band of the optic radiations, the inferior longitudinal fasciculus, passes first forwards and then backwards in the temporal lobe in its course from the external geniculate body to the occipital lobe   Partial hemianopia, i e, more or less

quadrantic defects, are then commoner than the typical homonymous hemianopia, and the defect is usually greater on the side of the lesion Subjective sensations of smell are an important symptom in these cases, and are due to the involvement of the uncinate process of the hippocampal gyrus

Lesions of the Optic Tract In this case, since the afferent pupillary fibres part company with the visual fibres before the latter enter the so-called primary optic centres—external geniculate body, pulvinar, and superior colliculus (*vide* p 60) —Wernicke's hemianopic pupil reaction should be present (*vide* pp 61, 93) It must be remembered, however, that this reaction is always difficult to elicit, and with the methods usually employed is seldom conclusive More assistance in diagnosis is afforded by collateral symptoms The proximity of the crus cerebri, third and other cranial nerves, leads to not infrequent involvement in the pathological process The association of hemianopia with contra lateral third nerve paralysis and ipsilateral hemiplegia suggests a tract lesion It is said that the fixation point does not escape in tract hemianopia Partial atrophy of both optic nerves manifests itself by pallor of the discs in these cases, preceded in cases of raised intracranial pressure by papilloedema The lesion is usually syphilitic meningitis or gumma, tubercle or tumour of the optic thalamus or temporo-sphenoidal lobe, softening and hæmorrhage are rare

Bitemporal hemianopia is usually caused by disease of the pituitary body which then presses upon the chiasma, so that the fibres going to the nasal halves of each retina are destroyed (Plate XX)

Disease of the pituitary body may manifest itself in forms which are attributed to (1) hyperpituitarism (2) hypopituitarism, and (3) dyspituitarism. The organ consists of a glandular anterior lobe, and a posterior lobe, composed of nervous tissue, covered anteriorly by a glandular veneer, the pars intermedia The anterior lobe appears to be specially concerned with skeletal growth, the posterior, including the pars intermedia, with tissue metabolism i e, over activity of the anterior lobe causes excessive growth in the bones, over activity of the posterior lobe leads to emaciation and glycosuria with polyuria, diminished activity of the posterior lobe leads to adiposity, sugar tolerance, sexual infantilism low pulse, low temperature &c (Cushing) Hyper pituitarism in infancy causes gigantism, in later life acromegaly Hypopituitarism causes adiposity and persistence of skeletal and sexual infantilism when originating in childhood, adiposity and

reversion to sexual infantilism, with development of feminine characteristics in the male, when originating in the adult (Fröhlich's syndrome). Hyperpituitarism often gradually gives place to hypopituitarism ; mixed or transition cases exhibit features of both states (dyspituitarism). The adiposity associated with defective action of the posterior lobe is accompanied by excessive
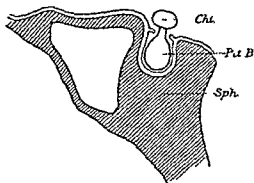
Fig. 221.—Antero-posterior section of sella Turcica   Pit. B., pituitary body.   Sph., sphenoid.   Chi., chiasma.
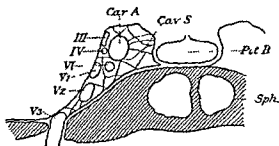
Fig. 222 —Transverse section of sella Turcica   Pit B., pituitary body.   Sph., sphenoid   Cav S., cavernous sinus   Car A., internal carotid artery   III, IV, VI, third, fourth and sixth nerves V_1, V_2, V_3, first, second and third divisions of the fifth nerve.

sugar tolerance, i e, 300 or 400 gms of glucose or lævulose can be assimilated without the development of glycosuria, whereas about 100 gms. is the normal amount. There is reason to think that some of the symptoms, e g., somnolence, adiposity, low temperature and possibly sexual impotence, are to be attributed to disorder of the neighbouring hypothalamus rather than to the pituitary gland itself. Changes in the pituitary body are accompanied by changes in other ductless glands, such as the thyroid, pancreas, testicles and ovaries.

Enlargement of the pituitary body, whether from functional hyperplasia, adenoma, or malignant growth, leads to visual defects in about 80 per cent of cases (Cushing), due to pressure upon the chiasma, which lies immediately above it (Figs 221, 222), and upon the inner sides of the optic tracts The earliest visual symptom is unilateral central scotoma, simu lating retrobulbar neuritis (Nettleship), for one side is usually compressed before the other This may be followed by homonymous hemianopia from pressure on one tract, or rarely by *altitudinal hemianopia*, *i e*, loss of the upper or more rarely lower halves of the fields, from pressure upon the chiasma, early loss in the upper half of the field may be caused by intra or extra sellar tumours, early loss in the lower half is in favour of a supra sellar tumour (Brouwer) More commonly temporal hemiachromatopsia, passing into a complete hemian opia, supervenes The field does not show the accurate delimitation characteristic of homonymous hemianopia, but gradually contracts from the temporal side inwards and from above downwards, finally involving the nasal field from below upwards and leading to complete blindness in the eye affected (Plate XX) Then, or at a much earlier stage, the vision of the other eye becomes affected in a similar manner If the second eye becomes affected before vision is lost in the first the fields show bitemporal hemianopia, but one eye is almost invariably more affected than the other, owing to the asymmetry of the growth Complete temporal hemianopia in one eye, for example, may be associated with temporal achro matopsia in the other Such cases emphasise the importance of charting the colour fields in all cases A considerable pro portion of cases show homonymous hemianopia, due to pressure and traction on one optic tract Variations in the progress of the visual defect are not uncommon In some cases headache disappears other symptoms are ameliorated, and the vision ceases to deteriorate Some of these cases are probably to be attributed to cysts which have ruptured spontaneously

If one eye is blind the history may reveal the fact that the field was lost earliest on the outer side. In cases of acromegaly, the enlargement of the jaw and characteristic facies, the large hands, the loss of sexual desire, and the presence of impotence or amenorrhœa, render the diagnosis easy Tumours of the hypophysis are less readily diagnosed but here also loss of sexual power is usually an early symptom, often accompanied by excessive subcutaneous fat In all cases a skiagram of the skull should be taken, and the sella Turcica will be found often,

PLATE XX.

Stage I
V—$\frac{70}{70}$

Stage II
V—$\frac{13}{40}$

Stage III
V—$\frac{70}{70}$

Stage IV
V—$\frac{70}{100}$

Stage V
V—$\frac{10}{100}$

Stage VI
V—$\frac{1}{100}$

Stage VII
V—Shadows

Stage VIII
V—Nil
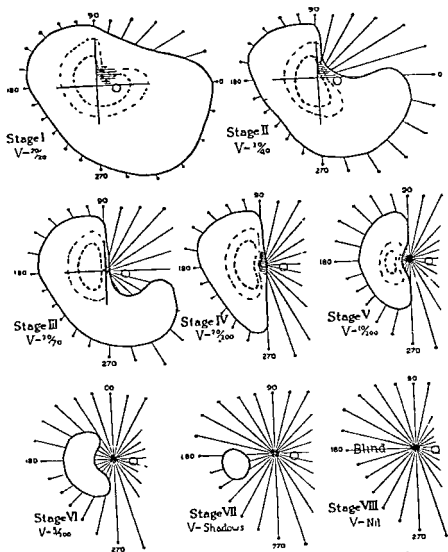
Showing the eight stages of a progressing right temporal field defect in pituitary disease. (Harvey Cushing and Clifford B. Walker)

PLATE XXI

7 6 5 4 3 2 1 0 9 8 7 6 5 4 3 2 1   1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7

D   C   B   A   A   B   C   D

Goldfinch may often be seen in a flock, their bright yellow • eye flashing in the sunshine as they dart from perch to plant to plant doing good service.

Maddox's scale to measure latent insufficiency or excess of convergence at the distance of 25 cm. with a prism of 12° (i. e., 6° deviation or 6Δ) base upwards before the R. eye. The figure to which the lowest arrow points indicates in degrees the amount of latent convergence (black letters) or divergence (red letters) which may be present. The figures under the waved line are—teens (ten, twelve, thirteen, &c.) and the capital letters, A, B, C, D, represent metre angles for an interocular distance of 64 mm.; if the lower arrow point to black, A, there is 1 metre angle (1 m.a. or 1 Δ) of convergence, if to black, B, 2 m.a., &c. The printed matter under the numbers is introduced to ensure accurate accommodation for the distance (25 cm).

though by no means invariably, enlarged Associated signs are slight proptosis and paralysis of ocular nerves, generally the first division of the fifth, causing pain, and the third nerve This is of diagnostic importance, since the sixth nerve is more commonly affected in intracranial lesions As already mentioned, Fisher regards Leber's disease (*vide* p 397) as probably due to pituitarism

Some cases improve when treated with thyroid extract others with pituitary extract, but spontaneous variations in the amount of visual defect are common Usually the cases come under observation at a late stage when over activity has given place to insufficiency Consequently, treatment with active extracts of the gland or of the anterior lobe is indicated If, as is usual, the progress of the visual defect remains unmitigated the question of operation arises, since otherwise total blindness from optic atrophy is inevitable The transfrontal route is preferred by neuro surgeons, and mortality has been much decreased by improved technique Death may occur from post-operative hyperpyrexia

Bitemporal hemianopia is occasionally due to basal syphilitic inflammation, or disease of the sphenoid It has also resulted from antero posterior rupture of the chiasma in fracture of the base of the skull

Binasal hemianopia is very rare, if, indeed, it can be said to occur at all in typical form It necessitates two lesions, one on each side of the chiasma, destroying the fibres to the temporal halves of each retina while leaving the nasal fibres intact In cases which have been reported there has usually been increased intracranial pressure with choked discs, and the condition has been attributed to distension of the third ventricle, causing the optic nerves to be pressed downwards and outwards against the internal carotids Other cases have been referred to atheroma of the carotids or posterior communicating arteries

Cases have been described in which there has been loss of half of one field and general blurring or amblyopia of the whole of the other In some of these cases a lesion has been found *post mortem involving one occipital lobe and extending* into the angular gyrus *Heteronymous amblyopia* has therefore been ascribed to lesion of the angular gyrus It is probable that this is merely a survival of the erroneous idea that the cortical representation of vision is in the angular gyrus It is probable that this gyrus has to do with visual conceptions, *i e*, mental visual impressions of a higher order than the perceptions represented in the occipital cortex

Amblyopia (ἀμβλύς blunt) and Amaurosis (ἀμαυρος, dark) are the terms used for partial and complete loss of sight respectively in one or both eyes They are not used of all cases of partial or complete blindness, but have become restricted to certain forms of a more or less indefinite character devoid of ophthalmoscopic or other marked objective signs

Unilateral amblyopia is usually either *congenital* (vide p 571) or from psychical suppression of the retinal image—*amblyopia ex anopsia* (vide p 571) these varieties are discussed elsewhere Unilateral amblyopia may be due to high refractive errors in the eye It is then not a true amblyopia, since correction with suitable glasses in early life cures the condition if sufficient perseverance is exercised In older people glasses often fail this may be attributed either to the development of a true amblyopia from disuse or, more probably, to defective receptivity of the higher centres Unilateral amblyopia is also a symptom of retrobulbar neuritis (q v)

Bilateral amblyopia is found in the various forms of toxic amblyopia (q v) Bilateral amaurosis occurs in uræmia and in meningitis Both amblyopia and amaurosis occur in hysteria

Uræmic Amaurosis occurs particularly in acute nephritis, e g , in pregnancy, after scarlet fever, &c , but is also found with chronic nephritis The onset of blindness is sudden or rapid (8–24 hours) , it is bilateral and complete The fundi show no changes unless as in some cases there is a coincident albuminuric retinitis Vision usually improves in 10–18 hours, and is fully restored in about 48 hours, especially if a lumbar puncture is done In cases during pregnancy there is usually eclampsia In uræmic amaurosis the pupils are dilated, but usually react to light It is probably due to circulation of toxic material which acts upon the cells of the visual centres The retained reaction of the pupils to light shows that the lower centres are relatively immune Exophthalmos sometimes occurs in cases of nephritis in which uræmia is present or imminent, and may therefore be of some prognostic significance It is accompanied by pain and limitation of movement of the eyes, and is probably due to œdema of the orbital tissues

Hysterical amblyopia as might be expected, exhibits protean manifestations It may be unilateral, but is more commonly bilateral There is usually concentric contraction of the fields, with or without colour defects A spiral field is very characteristic, i e , the field continually diminishes while it is being taken, so that it may be finally limited to the fixation point The patients, however, get about perfectly well unaided, an

impossibility in cases of genuine highly contracted fields (*vide* p 347) The condition is sometimes called anæsthesia of the retina an undesirable designation Sometimes there are irritative symptoms—blepharospasm, blinking, lacrymation, &c—hyperæsthesia of the retina The pupillary reactions are perfect, affording an invaluable objective diagnostic sign The prognosis in hysterical amblyopia is good, though treatment is usually tedious The chief difficulty consists in eliminating organic disease, such as retrobulbar neuritis, injury, embolism of the central artery of the retina, sympathetic ophthalmia, and so on

Amaurosis fugax is a term given to sudden temporary failure of sight and is a symptomatic condition due to various causes In its simplest form it occurs in normal people on rising suddenly from the sitting or recumbent to the upright posture. It is then due to the effects of gravity upon the blood and is merely momentary, accompanied by slight giddiness and even faintness Transient blindness, seldom complete, occurs as a prodromal symptom of obstruction of the central artery of the retina, and is probably due to spasm of the arteries or to the effects of changes in blood pressure associated with arterio sclerosis It has been met with in people with mild signs of Raynaud's disease Temporary amblyopia also occurs in migraine (*q v*) and in early stages of papilloedema (*q v*) from increased intracranial pressure

Scintillating Scotomata of various kinds occur in migraine In typical migraine the patient feels unusually well before the attack A positive scotoma appears in the field of vision, while obscuring sight it has a peculiar shimmering character It gradually increases in size until predominantly one half of the field is clouded, the fixation point remaining relatively clear In the dark field there are often seen bright spots and rays of various colours, and these are often arranged in zig zags and are then called fortification spectra (*teichopsia*) Both half fields are often affected, so that there is homonymous hemian opia In other cases the whole field becomes clouded, but usually even so the fixation point is seen momentarily, and then becomes obscured until the eyes are moved to a fresh spot Vision usually clears in about a quarter of an hour The attack is soon followed by violent headache, generally limited to the opposite side of the head to the hemianopic field (*hemicrania*), and accompanied by nausea and even sickness ("bilious attack") During the attack there is frequently numbness in the mouth and tongue and slight aphasia Attacks

occur periodically, but vary greatly in number and severity In mild attacks the scotoma or slight aphasia may occur without the headache and *vice versâ* In older persons subject to migraine only parts of the typical attack may occur, *e g*, the scotoma with little headache, or a migrainous headache without scotoms

Migraine is to be attributed to vaso-motor changes in the brain Vaso-dilatation, associated with a feeling of well being, is followed by vaso-constriction, especially in the occipital lobes There is often a copious secretion of urine of low specific gravity during the attack Constriction of the retinal arteries has been described during the scotomatous stage, but it is very doubtful if it ever occurs

Migraine occurs chiefly in highly strung people and is undoubtedly accentuated, if not caused, by chronic forms of peripheral nerve irritation especially such as are due to astigmatism, anisometropia &c Many cases but by no means all have been cured by accurate correction of the errors of refraction and the wearing of suitable glasses A sedentary life, with constipation and insufficient exercise, conduces to the attacks Rest, warmth, and sleep are the best cures for the actual attacks They can sometimes be warded off or alleviated by aspirin or ergotamic tartrate tablets Nitroglycerin or amyl nitrite have been used, but are not reliable cures

Occasionally people who suffer from ordinary migraine have attacks in which, without any scotoma the headache is followed by partial paralysis of the third nerve (*ophthalmoplegic migraine*) on the same side as the hemicrania Slight ptosis, diplopia and sluggishness of the pupil reactions continue for some hours and gradually disappear The paresis is worse and persists longer with succeeding attacks, and has sometimes eventually become permanent Probably most of these cases are not migrainous, but due to some organic nerve lesion, *e g*, pressure on the nerve by a congenital aneurysm of the circle of Willis, and some of the patients have died from subarachnoid hæmorrhage (*vide p* 607)

Night-blindness occurs *par excellence* in retinitis pigmentosa (*q v*) and in xerophthalmia (*q v*) In rare cases it is a familial congenital affection It is also found in endemic form, especially after exposure to bright sunlight in hot countries, *e g*, amongst soldiers and sailors The patients are usually overwrought, as by long marching or debilitated, as by scurvy, fasting in Lent, &c The condition generally improves rapidly if the eyes are protected and the nutrition attended to The affection is purely local, due to abnormal retinal fatigue,

as is shown by the fact that covering one eye with a bandage during the day has been found to restore sight enough for the ensuing night's watch on board ship, the unprotected eye remaining as bad as ever Night-blindness is to be attributed to interference with the functions of the retinal rods, due to deficiency in visual purple (Tansley) In xerophthalmia and the endemic cases the symptom is a manifestation of deficiency of fat-soluble vitamin A in the diet, and therefore cod liver oil is specially indicated It also occurs in diseases of the liver, especially cirrhosis Soldiers often complain of it, but not infrequently it is a functional nervous disorder in these cases, associated with other symptoms of neurosis or malingering

Day-blindness occurs in some cases of congenital amblyopia It also occurs in all cases of reflex blepharospasm In less noticeable form it occurs in lesions affecting the conducting paths of visual impulses, such as tobacco amblyopia, retro-bulbar neuritis, and the early stages of optic atrophy Patients suffering from these disorders often see relatively, and sometimes absolutely, better in a dull than in a bright light

Coloured Vision is sometimes complained of, and red is the colour usually noticed *Erythropsia* occurs particularly after cataract extraction if the eyes are exposed to bright light and are over strained In these cases it may persist for several hours or days Objects look red, but the visual acuity is not affected, and no permanent damage results Patients should be warned of the possibility of erythropsia, as it is somewhat alarming and suggestive of hæmorrhage It is met with also in snow blindness Red vision is sometimes complained of by neurotic hypermetropic children Chromatopsia also occurs in some cases during the resolution of optic neuritis when the ensuing atrophy is not complete In normal people black print will sometimes suddenly turn deep red this is due to strong lateral light entering the eye through the sclerotic

Metamorphopsia , Micropsia , Macropsia or Megalopsia , Photopsiæ (vide pp 337, 351)

Muscæ volitantes (vide p 328)

Colour Blindness or Achromatopsia may be congenital or acquired Acquired colour blindness, partial as in cases with relative scotomata or complete as in disease of the optic nerve, has been referred to incidentally in treating of the various disorders of the eye in which it occurs It may also be a symptom of disease of the central nervous system, especially perhaps the lowest parts of the occipital cortex In most diseases of the retina and choroid, e g , detached retina,

changes in colour perception affect mostly the blue end of the spectrum. Slight diminution in acuity of perception of these rays is caused normally, owing to their physical absorption, by the increase of amber pigment in the nucleus of the lens (*blue blindness*), and this may be abnormally great in sclerosing lenses (black cataract). It has been said to affect the pictures of artists in their old age (Liebreich). Slight absorption of rays of short wave-length is normal at the macula, owing to the yellow pigment present here ; it varies in different individuals.

Congenital Colour Blindness occurs in two chief forms, total and partial. The former is very rare and is always associated with nystagmus and a central scotoma. All colours appear grey, of different brightness. The spectrum appears as a grey band exactly like the normal scotopic spectrum (*vide* p. 68), and like it with the maximum brightness at 530 μμ. It does not change, except in increase of brightness, when the intensity is increased, but at moderately high intensity photophobia occurs. It is probable that total colour blindness is caused by defective development of cones or their complete absence.

The partial form is seldom discovered unless specially tested for, since the subjects compensate for their defect by attention to shade and texture, combined with experience. Gross cases occur in 3 to 4 per cent. of males, but are rare in females (0·4 per cent.) ; slighter cases are quite common in males. It is an inherited condition, being transmitted through the female, who is usually unaffected. In most cases reds and greens are confused, so that the defect causes grave danger in certain occupations, *e.g.*, railway signalmen, engine-drivers, and sailors. The red-green cases fall into two chief groups, protanopes and deuteranopes. For the former the red end of the spectrum is much less bright than for normal people and is often actually shortened. These groups are explained on the Young-Helmholtz theory by the hypothesis that one of the primary sensations (*vide* p. 69) is lacking. They are therefore often said to have dichromatic vision. In the protanopes the so-called red sensation is said to be absent, and they are called red-blind ; in the deuteranopes the green sensation is absent and they are called green-blind. On Hering's theory both groups are varieties of red-green blindness, which is explained as due to absence of the red-green substance (*vide* p. 69). In both groups the defects may not be complete and these cases are called protanomalous and deuteranomalous respectively. Since, on the Young-Helmholtz theory, all three sensations are represented, though one

is defective, these are said to have anomalous trichromatic vision It is clear that theoretically there might be other cases of colour blindness due to absence of the blue sensation or the blue-yellow substance, and such have been described, but are very rare (tritanopes).

There are two objects to be aimed at in testing for colour blindness (1) the exact scientific nature of the defect, (2) whether the subject is likely to be a source of danger to the community The first is exhaustive and may be the only means of arriving at the second, especially in the anomalous trichromats In the more difficult cases besides the simpler tests, more stringent tests with a pure spectrum should be employed In them only those of large experience will gather any useful information from the names given by the subject to various colours for these are named chiefly by reference to their various brightnesses and the answers appear to be quite inconsistent In testing for danger only, it is obvious that the names given to the colours are of value, for if a man repeatedly calls red green or *vice versâ* he is clearly unsuited to be an engine driver or look out man on a ship

Whatever the object in view, several tests should be employed For the spectrum tests the student must be referred to special monographs on colour vision The following are the chief other tests

(1) *The Lantern Test* The subject names various colours shown by a lantern, and is judged by the mistakes he makes Much depends upon the size of the apertures of the lantern (i e, the size of the retinal areas stimulated) and the nature and intensity of the light source Many lanterns are worse than useless The best is that used by the Board of Trade which has now been adapted to electric light Edridge Green's lantern is efficient if used by an expert

(2) *Holmgren's Wools* These consist of a large selection of skeins of coloured wools, and the candidate is required to make a series of colour matches

Test I consists in presenting to the candidate a pale green sample and telling him to select from the heap of wools all those which seem to correspond in colour If he is colour blind he will probably select several of the " confusion colours "—greys, buffs straw colour, &c—as well as greens He is next given a rose colour (II) if he matches this with blues or violets he is red blind , if with greys or greens he is green blind He is then given a bright red skein (III) if he is red

blind he will choose dark greens and browns, if green blind pale greens and browns   Sir William Abney has recommended the addition of two other tests   IV is a purple skein   if the candidate is colour blind he will probably select any shade of blue or green, also pinks and greys   V is a yellow skein   the colour blind candidate will probably select greenish yellows, light yellow greens, fawns and pinks   In blue-blindness purples, red and orange are confused in test II

Holmgren's wools have been much criticised, but if the tests are properly carried out gross defects of colour vision are easily recognised and an expert will be put on his guard in almost every case of even minor defect.

(3) *Stilling's Tests*   These consist of coloured lithographic plates, in which bold numerals are represented in dots of various tints set amid dots of the same size but of tints which are most readily confused with those of the figures by colour blind people   Normal trichromats can easily read the numbers, some of which are indistinguishable to the various types of colour blind   Ishihara's tests are a modification and, in some respects, an improvement on Stilling's   they include tests in which the numbers can be read by the colour blind but not by the normal sighted

(4) *Nagel s Anomaloscope*   This is an instrument in which on looking down a telescope a bright disc is seen, divided into two halves by a horizontal line   One half is illuminated by light of the sodium line of the spectrum (yellow), and this has to be matched by a mixture of red (lithium line) and green (thallium line) in the other half   By turning a screw the relative amounts of red and green in the mixture can be varied   By turning another screw the brightness can be varied

Defects of colour vision have led to much acrimonious discussion   Their detection may be easy, but is often difficult   No theory which has yet been brought forward is wholly satisfactory, and no single test is infallible

Malingering   Cases occasionally occur of men who hope to gain some advantage by pretending to be blind   It is rare for complete blindness to be assumed, and such cases can only be detected by constant watching of the person's behaviour   When one eye is said to be blind, in spite of absence of sufficient objective evidence to account for the condition, the demonstration of malingering resolves itself into a contest of wits between the surgeon and the individual   Many tests have been devised, and several should be employed in each case

(1) A low concave or convex glass (O 25 D) is placed before the "blind" eye, and a high convex (+ 10 D) before the "good" eye, and the examinee is told to read the distant types If he succeeds malingering is proved

(2) A prism is placed base downwards before the "good" eye and the examinee is told to look at a candle If he admits to seeing two candles malingering is proved

(3) The surgeon stands behind the patient and covers the "blind" eye with his hand at the same time holding a prism of 10 degrees base down before the "good" eye in such a manner that the edge of the prism passes horizontally across the centre of the pupil Uniocular diplopia results The surgeon then simultaneously removes his hand from the "blind" eye and shifts the prism upwards so that the whole pupil is covered by it If the examinee still admits to seeing two candles malingering is proved

(4) While the examinee looks at a candle a prism of 10 degrees is placed base outwards before the "blind" eye If the eye moves inwards in order to eliminate diplopia it is not blind

(5) Snellen's coloured types may be employed The letters are printed in green and red If a red glass is placed before the "good" eye, and the patient reads all the letters the other eye is not blind, for the eye looking through the red glass can only see the red letters Care must be taken in this test that the red glass cuts off all the rays from the green letters as tested by the surgeon's own vision

Word-blindness occurs as a not very uncommon congenital defect—0 1 per cent of elementary school children (Thomas) It is much commoner in boys than girls Owing to backwardness in learning to read the children are often brought to the ophthalmic surgeon, visual defect being suspected In spite of normal fundi and often quite normal acuity of vision, the patients fail to recognise printed or written words The auditory memory of words is unimpaired, and generally numerals and music can be read Hence the patients learn well orally, and are good at arithmetic They are often quite intelligent and may be wrongly punished for inattention and stupidity The condition sometimes runs in families The defect is not necessarily complete and much improvement can be obtained by careful individual tuition and perseverance

CHAPTER XX

Intra-Ocular Tumours

INTRA OCULAR tumours are rare, but of great importance, since they are usually malignant and endanger the life of the patient

Tumours of the Iris   Sarcoma of the iris is extremely rare It is not uncommon to see irides with dark brown spots (melanomata) due to congenital aggregations of retinal pigment epithelium   As a rule these are benign, but occasionally they take on malignant proliferation   Any increase of size must be watched with suspicion   True sarcoma, composed of pigmented or unpigmented spindle-shaped or round cells, occurs as an isolated nodule   It grows rapidly, and if left attacks the corneo-sclera and perforates the globe   It gives rise to meta stases from which the patient dies

Although it is the only new growth of importance met with in the iris it may be diagnosed from gumma or tubercle only with difficulty   The chief points of difference are the absence of inflammation as shown by synechiæ, &c, the absence of satellites, the frequency of pigmentation, and the rapid increase in size

Treatment   The growth should be watched for a short time and if found to increase in size should be removed by iridec tomy if this is feasible   The specimen is subjected to expert microscopic investigation   If the growth is malignant and has not been completely removed or shows signs of recurrence the eye must be excised at once, if completely removed the prognosis is good

Sarcoma of the Choroid is not so rare as sarcoma of the iris The growth arises from malignant proliferation of the stroma cells of the outer layers   It forms at first a lens shaped mass raising the retina over it   By the process of growth increased tension is thrown upon the elastic membrane of Bruch, which finally ruptures   The cells then proliferate through the opening and form a globular " head " in the subretinal space, separated from the mass in the choroid by a narrow " neck " (Fig 223) The retina remains in contact with the tumour at the summit of the head, but is detached from the choroid at the sides, the

intervening space being filled with albuminous fluid   The growth may be in any situation, and the fluid may sink down to the lowest part of the eye, forming there a " simple " detachment isolated from that over the tumour   As the tumour progresses the retina is more and more detached, until no part remains *in situ*   The nutrition of the lens then suffers, so that it becomes opaque   The tumour may fill the globe before perforating the sclerotic, or this may occur relatively early along the perivascular spaces of the vortex veins or ciliary vessels   The orbital tissues then become infiltrated   The
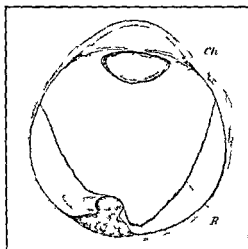
Fɪɢ 223 —Section of sarcoma of the choroid (× 9) showing the typical mushroom shape   *Ch* , pars plana of ciliary body continuous posteriorly with the choroid behind *R*, retina

lymphatic glands are not affected, but metastases occur in the liver and elsewhere

The growth is usually pigmented—melanotic sarcoma , rarely unpigmented—leucosarcoma   The cells are usually spindle shaped   They may be cylindrical or palisade like, arranged in columns, or around blood vessels (angiosarcoma), or the cells may be endothelial   Most sarcomata are mixed celled   Silver staining reveals a variable amount of argyrophile " reticulin " fibres, generally most in spindle celled sarcomata There is evidence that those with most reticulin are least malignant

Evidence has recently been brought forward to show that sarcomata of the eye are derived from the cells of the sheaths of

Schwann of the ciliary nerves (*cf* p 645) As these are ectodermal in origin the growths are now often called *malignant melanomata* Even if this origin is confirmed the name is ill-chosen, since the growths are not always pigmented

The course of sarcoma of the choroid is commonly divided into four stages (1) the quiescent stage, (2) the glaucomatous stage, (3) the stage of extra-ocular extension, (4) the stage of metastasis This is probably the typical chronological order of events, but secondary glaucoma may arise at a very early stage or be delayed until after extra-ocular extension has taken place, and there is evidence to show that metastases may occur at an early stage

The cause of the glaucoma is obscure in most cases it is due to the lens and iris being forced forwards, so that the angle of the anterior chamber becomes blocked In other cases, particularly those of early onset, obstruction to the venous out flow from the eye is the probable explanation, the tumour being in some instances so situated as to press upon a vortex vein

Sarcoma of the choroid usually occurs in adults between forty and sixty It is always primary, single, and unilateral The patient may come under observation in the early stage when there is only detachment of the retina The earliest cases to seek advice are those in which the tumour is near the macula, since vision is then most strikingly affected In other cases the tumour has usually attained a considerable size, and the patient may apply for treatment for relief of the pain of glaucoma

It is of the utmost importance that the cause of the detachment of the retina should be diagnosed in these cases We have already seen that "simple" detachment of the retina is most frequently found in myopic eyes or after a blow, though many cases are apparently ' idiopathic " In simple detachment the lower part of the retina is usually affected, though not always There is therefore presumptive evidence—of only slight weight—that a detachment in the upper part is due to a tumour of the choroid In detachments of considerable size the tension of the eye is normal or subnormal in the absence of a growth, if the tension is raised quite definitely a growth may be diagnosed almost with certainty A simple detachment shows numerous, more or less parallel, folds, and undulations can be seen to travel over the surface when the eye moves The detachment at the summit of a tumour is usually rounded and fixed, though in the surrounding parts it may show all the signs of a ' simple detachment Patches of pigment upon the

f

rounded part support the diagnosis of a tumour, but pigment disturbance, more particularly at the periphery, is not uncommon in simple detachment   Rarely a system of blood vessels having an entirely different mode of distribution from the retinal vessels can be made out between the latter vessels   This is the most positive evidence of growth, but it is only occasionally seen   A very small, round detachment in the macular region or upper part of the globe is almost certain to be due to a tumour of the choroid   If the detachment is sufficiently anterior, transillumination with a specially devised lamp will afford assistance in diagnosis   After anæsthetising the eye and dilating the pupil with homatropine the minute lamp is placed in contact with the eyeball as nearly as possible over the situation of the growth and the pupil observed in the dark room   In cases of doubt when the suspected neoplasm is situated behind the equator it is justifiable to incise the conjunctiva and Tenon's capsule and pass posteriorly over the sclera a specially constructed small transillumination lamp to the site of the growth   A simple detachment is transparent, a choroidal growth opaque

Diagnosis may be extremely difficult if the patient is first seen when glaucoma has already supervened   Dependence must then be placed largely upon the history   Defective vision may have been noticed, but the premonitory haloes of glaucoma have been absent, and vision has gone from bad to worse without remissions   One eye only is involved   The other may be perfectly normal, or at least not of the glaucomatous type with small cornea and so on, and the field of vision in this eye will show no contraction on the nasal side   The affected eye will probably have no perception of light, so that if any doubt remains it should be excised

Treatment   The eye should be excised as soon as possible after arriving at the diagnosis   Although sarcoma of the choroid rarely travels down the nerve, it is wise to cut it as long as may be   If the growth has already burst through the globe the orbit should be exenterated, or irradiated with X-rays or radium   When the affected eye is the only seeing eye the choice of excision or treatment by suturing radon seeds to the sclera over the site of the neoplasm (*vide* p 425) should be put before the patient

The disease is invariably fatal, usually within five years, if not eradicated by operation   metastases may be delayed for ten years or more   Prognosis is fair if the tumour is small and entirely intraocular especially if it contains much reticulin (*vide* p 419)

Flat Sarcoma of the Choroid In rare cases the choroid becomes infiltrated with sarcoma cells which cause a uniform thickening and shallow ' detachment " of the retina These are probably endotheliomatous, spreading along the lymphatic spaces of the choroid in the same manner as secondary carcinoma (q v)

Sarcoma of the Ciliary Body is fundamentally of the same nature and gives rise to the same symptoms as sarcoma of the choroid the differences being only those dependent upon the anatomical disposition of the parts Thus the retina being here more adherent to the underlying uvea, and being reduced to a double layer of epithelial cells, is not detached When the growth has spread to the choroid the retina proper becomes detached The tumour may attain considerable size before it causes symptoms, which are then referable to displacement or distortion of the lens and interference with the ciliary muscle The ciliary circulation is impeded, and conspicuous dilatation of one or two anterior perforating ciliary vessels should always arouse suspicion The growth may invade the angle of the anterior chamber It then has the appearance of an iridodia lysis a dark crescent showing at the root of the iris That it is not an iridodialysis is shown by the fact that no reflex can be obtained through it on illuminating with the ophthalmoscopic mirror and from the absence of history of a blow In the case of a leucosarcoma the crescent may be yellowish but vessels will usually be visible upon the surface, and these render the diagnosis easy The growth may be visible by oblique illumination with a widely dilated pupil, and is opaque to transillumination

Sarcoma of the ciliary body is less common than that of the choroid The treatment and prognosis are the same

Ring or Annular Sarcoma of the Ciliary Body resembles flat sarcoma of the choroid in its infiltrating character It is very rare

Secondary Carcinoma of the Choroid occurs sometimes in late stages of scirrhus of the breast, more rarely in cancer of other organs There is obscuration of vision and ophthalmoscopic examination reveals a widespread shallow detachment of the retina, usually at the posterior pole The disease is nearly always bilateral, and as it is usually only one of many meta static deposits and the patient is generally in the last stages of general carcinomatosis no special treatment is indicated

Glioma of the Retina (*Syns* —*Neuro-epithelioma retinæ Retinoblastoma, Retinocytoma*) is a malignant disease having no relationship whatever to " glioma " of the central nervous system It is confined to infants, and is probably always

congenital, though it may remain quiescent or pass unnoticed until the fifth or sixth year or even later   The disease is rare, the second eye is affected, independently and not by meta stasis, in about one fourth of the cases, but frequently the growth cannot be recognised even on careful examination until after months or even years   Several children of the same family are sometimes affected

The child is brought to the surgeon on account of a peculiar yellow reflex from the pupil sometimes called "amaurotic cat's eye"   If left untreated glioma runs through the same stages as sarcoma of the choroid, viz, (1) the quiescent stage, (2) the glaucomatous stage, (3) the stage of extra ocular extension, (4) the stage of metastasis   The second stage results in enlargement of the globe, with apparent or real exophthalmos   Pain is severe during this stage, but is relieved when the tumour bursts through the sclerotic   Perforation often occurs at the limbus and is followed by rapidly fun gating growth   Metastasis first occurs in the preauricular and neighbouring glands, later in the cranial and other bones Direct extension by continuity to the optic nerve (which is early affected) and brain is commoner, and metastases in other organs usually the liver, is relatively rare (*cf* Sarcoma of the Choroid)   In most cases the first stage lasts from six months to a year

The growth consists chiefly of small round cells with large nuclei resembling the cells of the nuclear layers of the retina, masses of these stain badly showing that they are undergoing necrosis (Fig 224)   Among them may be found rosette like formations of cells resembling the rods and cones   Such rosettes are also found in microphthalmia, and have been produced in embryonic eyes by irradiation and by trephining undeveloped rats eyes (Tansley)   The growth probably originates in an island of undifferentiated embryonic retina which has failed to develop normally

It is a disease *sui generis* and as already mentioned, bears no resemblance to glioma of the brain from which it must be carefully distinguished   It probably originates in foetal, undifferentiated retinal cells   when the other eye is affected it is a separate focus and not an extension *via* the chiasma   It is invariably multiple (*cf* Sarcoma of the Choroid) When seen very early, as for example in the second eye a larger mass is seen surrounded by numerous punctate satellites Microscopically, minute deposits are seen scattered in various situations throughout the globe   It may grow principally

outwards, separating the retina from the choroid (*glioma exophytum*), or inwards towards the vitreous (*glioma endophytum*).   There is no fundamental distinction, but the ophthalmoscopic appearances differ in the two types   In the former the condition resembles a mere detachment of the retina , in the latter polypoid masses may be seen stretching into the vitreous. Hæmorrhages upon the surface are not uncommon, especially in glioma endophytum.

Several conditions occurring in children may give rise to

Fig 224 —Section of glioma of the retina (× 3)   Note the rings of deeply stained cells surrounding blood vessels , also the infiltration of the anterior part of the optic nerve

similar signs, and cause great difficulty in diagnosis. These have been grouped together under the term *pseudoglioma*. The chief are (1) inflammatory deposits in the vitreous, with or without detachment of the retina ; (2) tubercle of the choroid, especially the confluent type ; (3) congenital defects, due to persistence of part of the fibro-vascular sheath at the back of the lens. The first group are due to a quiet form of cyclitis, which may have passed unnoticed or may have caused slight redness of the eyeball with inflammatory deposits in the anterior chamber ; these, however, are usually soon

absorbed A history of fits, unconsciousness, attacks of
screaming, ear disease, meningitis (especially post basic), one
of the acute specific fevers, syphilis, &c , may be obtained
Iritis, or the results of iritis or iridocyclitis, *e g* , posterior
synechiæ, retraction of the base of the iris, and so on, are often
present

In all cases atropine should be instilled and both eyes should
be thoroughly examined opthalmoscopically, under general
anæsthesia if necessary The tension may then be satisfactorily
tested and may afford useful information which cannot be
obtained without an anæsthetic Raised tension is in favour
of glioma, lowered of pseudoglioma Even when every
precaution is taken there is a considerable group of cases in
which it is quite impossible *to be certain of the diagnosis*
Considering that the life of the patient is at stake and that
the eye is in any case useless as an organ of sight, these cases
should be treated as glioma

Treatment The treatment of glioma is excision of the eye
at the earliest possible moment The optic nerve should be
cut long, and the cut end invariably submitted to microscopical
examination If there is any doubt of extension of the disease
to the conjunctiva or orbital tissues exenteration of the
orbit is imperative In cases where the diagnosis is doubtful
the eye should be removed, for in inflammatory pseudoglioma
the eye is destined to shrink and become unsightly In no
case should both eyes be removed at the same operation, but
if one is proved by microscopical examination to be glio
matous and the other contains gliomatous nodules, it is
justifiable to treat these by the application of a 2 millicurie
radon seed stitched to the sclera over the site of the nodule
When the growth is situated near the macula and optic disc
the radon seed or seeds may be embedded in a strip of Stent
wax moulded over the appropriate site The Stent is kept in
position by stitching it to the sclera at about the equator

There is histological evidence that a 2 millicurie radon seed
destroys the growth for a radius of at least 3 5 mm around it
The number of seeds required will depend upon the size of the
neoplasm , four is the maximum yet used with good results
Late sequelæ of irradiation are thin greyish exudates at the
macula eighteen months, and posterior cortical lens opacities
from 9 months to 8 years after treatment Some patients
are still alive eleven and twelve years after radon treatment
Radon seeds should be used only in bilateral glioma, or when
excision of the eye is absolutely refused

The prognosis of glioma, if untreated, is absolutely bad, the patient invariably dying. The prognosis is fair if the eye is removed before extra-ocular extension has occurred. In the absence of disease of the second eye the patient may be regarded as out of danger if there is no recurrence in the orbit within three years, but the remaining eye should be carefully examined under atropine at frequent intervals for a much longer period. There are several cases on record of cure after removal of both eyes for glioma retinæ.

CHAPTER XXI

Injuries to the Eye, Panophthalmitis, and Sympathetic Ophthalmia

THE eye is protected from direct injury by the lids and the projecting margins of the orbit   Nevertheless, it is not exempt from foreign bodies, the action of caustics, contusions by blunt and wounds by sharp instruments.

FOREIGN BODIES, BURNS, &c.

Foreign Bodies, which are usually small—particles of coal dust, emery, steel, &c—may pitch upon the conjunctiva or upon the cornea   In the former case they cause sudden discomfort and reflex blinking   The foreign body sticks to the palpebral conjunctiva and is liable to be dragged across the cornea, which it excoriates   It may get floated by tears towards the inner canthus, and so into the nasal duct   Very frequently it becomes lodged at about the middle of the upper sulcus subtarsalis (*vide* p 615), where it is most likely to irritate the cornea, or in the upper fornix   It may occasionally become imbedded in the bulbar conjunctiva   Quite large foreign bodies, such as a grain of corn, may be retained for a long time in the upper fornix and give rise to much irritation and some discharge   They are liable to be overlooked unless the upper lid is everted   They are generally imbedded in a mass of granulation tissue, which may simulate the cockscomb type of tubercle (*vide* p 182)

Fragments of aniline pencil in the eye cause much irritation and a very unsightly staining   The eye should be irrigated with a weak solution of alcohol, and glycerine drops used (Swanzy and Werner), since these substances are solvents of aniline violet

Particles of steel and emery are very liable to fly straight on to the cornea and penetrate into the epithelium or substantia propria   Larger particles of steel, or less commonly stone, glass, &c , may perforate the globe (*vide* p 447)   When situated in the cornea they cause great pain and irritation   The pupil is often constricted   If allowed to remain they expose the cornea to the dangers of infection by organisms

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in the conjunctival sac and ulceration This may lead to a
small superficial slough being cast off carrying the foreign
body with it The small ulcer thus formed may heal but if
virulent organisms are present a spreading ulcer with or
without hypopyon may develop

It is not always easy to discover a foreign body upon the
cornea If situated eccentrically on the cornea a leash of
conjunctival blood vessels will be dilated on this side and will
point in the direction of the foreign body In case of doubt
the eye should be anæsthetised and the cornea thoroughly
examined under oblique illumination and a loupe The use
of fluorescein will sometimes but not always reveal the
position In some cases the foreign body can be detected

by reflecting light into the
eye with a plane mirror
especially if a convex lens is
used to magnify the object
(*vide* p 235)

The binocular corneal
microscope is of great assist
ance in determining the posi
tion and nature of the foreign
body When combined with
illumination by the slit lamp
the depth of an embedded
foreign body can be measured
by the aid of a micrometer, or
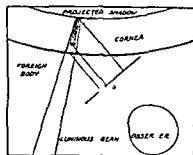
Fig 225—Slit lamp illumination
(Koby)

estimated by the length of the shadow which it casts (Fig 225)

The wing cases of insects and the husks of seeds may adhere
by their concave surfaces to the cornea usually at the limbus
for several days or even weeks

Treatment Foreign bodies must be removed as soon as
possible and as far as possible with antiseptic precautions
If situated in the lower fornix they are easily removed with
a clean handkerchief after everting the lower lid If not
found in this position the upper lid should be everted (*vide*
p 80), the particle will generally be found in its favourite
situation and can be removed in the same manner or by
passing the finger over the surface If it is still not seen
the upper fornix should be brought into view (*vide* p 81) and
the particle removed In case of difficulty previous applica
tion of pantocain will materially assist

If the foreign body is imbedded in the bulbar conjunctiva it
should be picked out by a needle after application of pantocain

If a discussion needle is not at hand a darning needle may be used, it should be passed through a flame first, so as to sterilise it. This little operation is performed in the same manner as removal of foreign bodies from the cornea (*vide infra*). It may be necessary to snip off the small piece of conjunctiva containing the foreign body with scissors.

Removal of foreign bodies from the cornea is effected as follows. The eye is anæsthetised and the patient seated in a chair. The surgeon stands behind the patient and holds the lids apart with the first and second fingers of his left hand pressing slightly backwards so as to steady the globe. An assistant focusses the light upon the cornea, the patient being told to look in the direction which affords the best view of the particle. An attempt may first be made to remove the foreign body by touching it with a slip of clean blotting paper, which exercises a capillary attraction. If this fails a sterilised spud (Fig 226) is used. Only if this too fails after repeated efforts should a needle be resorted to. It may be a discussion needle or in default of that a darning needle (*vide supra*). The greatest care should be exercised not to scrape up the epithelium more than is absolutely necessary. Emery and steel particles cause a little ring of brown stain around them, which should be scraped off, if this is not done the patient is likely to return, under the impression that the foreign body has not been removed. If there is any sign of ulceration, e.g., greyish infiltration around the abrasion and *the patient is young with normal tension*, a drop of 1 per cent atropine should be instilled, warning being given that the sight will be misty for a few days. If the patient is over forty or has any signs indicative of the possibility of glaucoma arising (*vide* p 281) atropine should be avoided and the eye should be examined daily for a time. *Atropine should not be used as a routine measure. It is generally unnecessary*, and it always involves prolonged absence from work and consequent economic loss. In every case parolein is instilled, and the eye is kept bandaged for a day, and boric lotion is ordered. If ulceration occurs it is treated in the appropriate manner (*vide* p 204). Special attention should be given to particles of stone which show a greater tendency than steel,

Fig 226.— Spud for removing foreign bodies from the cornea

&c , to cause ulceration, probably because steel particles are often hot, and therefore sterile, when they enter the eye

Occasionally sharp steel and other particles penetrate deeply into the cornea, without, however, perforating The efforts made to remove them may push them still deeper or even into the anterior chamber When such an accident is feared special precautions must be adopted If the particle is steel and a large magnet e g , Haab's or Mellinger's, is available this method should be tried (*vide* p 455) , it is often necessary to incise the cornea overlying the foreign body This method may fail, the particle being so small that an insufficient number of lines of force pass through it In these cases, or when the particle is non magnetisable, a broad needle should be passed into the anterior chamber and pressed against the back of the cornea while the foreign body is being removed with a needle Usher has invented a spatula, curved on its anterior surface to fit the back of the cornea, for this purpose, it is introduced into the anterior chamber through a keratome incision If the foreign body escapes into the anterior chamber it must be removed by other methods (*vide* p 453)

Prophylactic Measures Foreign bodies in the eye are extremely common in industrial workers especially in grinding tools, lathe work &c Apart from the danger to the sight of the worker, they are a source of great economic loss from loss of time compensation &c They could in most cases be entirely prevented by the use of protective goggles but it has hitherto been found impracticable to enforce this measure among British workmen Every attempt should be made by the provision of comfortable goggles and by educative means, such as " Safety First " notices and lectures by welfare officials, to point out the dangers and to encourage the workmen to use goggles

Burns and Injuries by Caustics Burns by hot water or steam, hot ashes, exploding powder, molten metal, &c , and injuries by caustics, such as lime, usually from fresh mortar or whitewash, strong acids and alkalies &c , endanger the eye chiefly in two ways, viz , by injuring the cornea and by producing symblepharon Strong ammonia is particularly harmful, causing necrosis of the cornea , hydrochloric acid (spirits of salt) much less so Many eyes have been lost through cutting open golf balls the central core often contains caustics (barium sulphate, caustic soda etc) which spurt into the eye Immediately after the accident there is intense conjunctivitis and chemosis, but the cornea looks clear , in this state it is difficult to be certain of the extent of

the injury A drop of fluorescein solution will reveal the
extent of the area denuded of epithelium Prognosis should
therefore be guarded, care being taken to impress upon the
patient the gravity of the injury and the necessity for constant
supervision In the worst cases the cornea is dull or opaque
In the succeeding days an eschar forms and is thrown off
This is followed by granulation of the injured conjunctiva
and frequently by ulceration of the cornea The corneal
condition must be treated like a corneal ulcer (*vide* p 204).
In bad lime burns, &c , the whole cornea may be destroyed,
perforation takes place, and the eye shrinks In less severe
cases a dense leucoma forms, porcelain like in lime burns,
and sight is lost The chief danger derived from the con
dition of the conjunctiva is that of adhesion of the lid
to the globe It is most likely to occur with the lower
lid the caustic acting principally upon the lower fornix,
which is obliterated by organisation of the granulation
tissue The symblepharon thus produced impedes the move
ments of the globe and may even interfere with its nutrition
Every precaution must be adopted to prevent its occurrence

Treatment In the earliest stages of injury by caustics the
excess of deleterious material must be removed Acids may
be neutralised by dilute alkalies (lotio sodii bicarbonatis, 3 per
cent) and alkalies by weak acids (lotio acidi borici) or milk
Particles of lime must be perseveringly picked out with
forceps, after previous application of pantocain irrigation with
10 per cent solution of neutral ammonium tartrate is painful
but undoubtedly diminishes scarring in lime burns A few
drops of oil ricini or parolem may be instilled

To prevent symblepharon a glass rod is well coated with
vaseline or boric acid ointment, or if the cornea is involved
atropine ointment, and the point is swept round the upper and
lower fornices, so that they are well packed with ointment
In severe cases cold compresses should be applied, and the
patient put to bed

Recently good results have been obtained by excising all
damaged bulbar conjunctiva up to the limbus and down to
the sclera If the raw area thus left is small and there is
enough conjunctiva available it may be covered by a con
junctival flap, but if it is large a graft of buccal mucous
membrane is taken from inside the lower lip and sutured in
position Parolem is instilled, and the closed lids covered
by a layer of tulle gras, a pad wrung out in saline and a crêpe
bandage

In the succeeding days if symblepharon still threatens, the treatment with ointment and the glass rod is repeated once or more times daily according to the severity of the case   A contact glass coated with sterile vaseline inserted over the cornea and conjunctiva assists in preventing symblepharon   If symblepharon occurs it must be suitably treated (*vide* p 631) but prevention in this case is easier than cure   If the actual fornix is denuded of epithelium it may be impossible to prevent symblepharon

CONTUSIONS BY BLUNT INSTRUMENTS

Injuries by blunt instruments vary in severity from a simple corneal abrasion to rupture of the globe   There is no part of the eye which may not be so injured by contusion as seriously to diminish vision   Moreover, in some cases the changes are progressive so that *in all cases a very guarded prognosis should be given*   The various conditions which may follow contusion will be briefly enumerated

Cornea   A simple *abrasion* may be caused   It is recognised by distortion of the corneal reflex and by the use of fluorescein (*vide* p 87)   There is much pain, like that due to the presence of a foreign body, increased on moving the lids, much lacrymation and reflex blepharospasm   It may become infected and give rise to a corneal ulcer, especially if a mucocele is present (*vide* p 651)   In the simple cases the use of a lotion, *e g*, boric acid boric ointment to prevent the lids from sticking together, and a pad and bandage for a few days suffices (cf p 429) Ulceration must be treated suitably (*vide* p 204)

Recurrent Erosion (Syn —Recurrent Traumatic Keratalgia) is particularly liable to occur after scratches with babies finger nails   The abrasion however produced usually heals quickly, but is followed some days weeks or even months later, by acute pain and lacrymation generally on first opening the eyes in the morning   If the cornea is then stained with fluorescein an abrasion will be found usually at the original site but sometimes elsewhere, or there may be a vesicle or group of vesicles   The attack rapidly passes off with appropriate treatment but often recurs again and again   There is no doubt that in these cases the epithelium is abnormally loosely attached to Bowman's membrane, and is liable to be torn off by the lid on waking   Such looseness of epithelium and formation of vesicles is characteristic of lesions of the fifth nerve (*vide* pp 229 230) and it is probable that recurrent erosion is due to this cause though the actual rationale is unknown   Early attacks should be treated in the

same manner as a simple abrasion boric ointment being plentifully applied at night Instillation of 1 per cent pantocain relieves the pain and seems to have a good effect on the epithelium If the attacks are repeated the spots should be curetted and touched with pure carbolic acid (*vide* p 217) mild application of X rays has been found beneficial (Greeves) (*vide* p 234)

Deep opacity may be found, usually in the form of delicate grey striæ interlacing in different directions They are due to accumulation of lymph in the interlamellar spaces, occasionally to wrinkling of Descemet's membrane (*vide* p 248) They generally clear up without leaving a permanent opacity

Examination with the slit-lamp has shown that all contusions of the eyeball are followed by the deposition of fine granules of uveal pigment on the posterior surface of the cornea There may be ruptures in Descemet's membrane, owing to its elasticity the edges are rolled over

Blood staining of the cornea occasionally results from contusion which has caused hæmorrhage into the anterior chamber Probably in all the cases the tension of the eye is raised in the early stages The whole cornea is at first stained, the colour varying according to the duration of the condition It may be reddish brown or greenish In the latter case the condition nearly simulates dislocation of the clear lens into the anterior chamber (*vide* p 436) The cornea gradually and very slowly clears from the periphery towards the centre, the whole process taking two years or more Microscopically there are myriads of minute, highly refracting rods packed in the lamellæ of the substantia propria, and sometimes round granules of pigment in the corneal corpuscles These are derivatives of hæmoglobin, which may or may not contain iron They are probably removed by the phagocytic action of leucocytes—a slow process In the absence of other cause of defective vision sight may eventually be completely restored

Rupture of the cornea is very rare Descemet's membrane may be ruptured alone In complete rupture an attempt may be made to save the eye by suturing the cornea with a special needle (Fig 272)

Sclerotic Rupture of the globe is generally due to it being suddenly and violently forced against the orbital walls It is often due to falls upon some projecting object, such as a knob or a key in a door, and has been frequently caused in country districts by a blow from a cow's horn The force is usually applied from the direction down and out, where the eyeball is

least protected by the orbital margin, the eye is forced into contact with the pulley of the superior oblique muscle The sclerotic gives way up and in at its weakest part, viz, in the neighbourhood of the canal of Schlemm The wound is oblique, being farther forwards internally than externally, where it appears more or less concentric with the corneal margin and about 3 mm behind it The conjunctiva is often intact, but there are always severe injuries to other parts of the eye The iris is generally prolapsed or torn away (iridodialysis) or retracted The lens may be expelled from the eye or escape under the conjunctiva (subconjunctival dislocation of the lens) or be forced back into the vitreous, making the anterior chamber deep The anterior chamber contains blood (hyphæma), and there may be hæmorrhage into the vitreous Detachment of the retina may occur, with or without subretinal or subchoroidal hæmorrhage The eye usually shrinks and is lost

Treatment The eye must be carefully examined with lid retractors, under an anæsthetic if necessary In severe cases nothing remains but to excise the collapsed globe In less severe cases without extrusion of the contents of the globe atropine may be instilled, cold compresses applied, and the patient kept in bed Sometimes good results follow suture of the rupture If the rupture involves the periphery of the cornea the iris alone may be prolapsed It is then a good plan to insert the sutures in the sclerotic without tying them before excising the prolapse, they are then tied

In subconjunctival dislocation of the lens it would seem a natural procedure to open the conjunctiva and let out the lens This is, however contraindicated in the early stage It must be remembered that there is an opening directly into the vitreous, and that such a procedure will almost inevitably involve escape of vitreous and possibly panophthalmitis Atropine should be instilled and cold compresses applied The lens will gradually become absorbed but no harm will accrue if the remnants are removed after the scleral rupture has healed

Iris Most injuries to the iris caused by contusion are due to sudden incurving of the cornea whereby the aqueous is forced back against the iris and lens

Traumatic mydriasis may follow a contusion The pupil is large and immobile and usually remains moderately dilated permanently It is due probably to paralysis of the motor nerve fibres, which may be stretched or torn in their passage

through the ciliary body   There are minute ruptures in the pupillary margin, but these do not account for the immobility There is usually also paralysis of accommodation   *Traumatic miosis* is rarer, and results from less severe injuries, it usually passes off   *Radiating lacerations* of the iris, sometimes extending to the ciliary margin, are rare (Fig 227)   *Iridodialysis* is commoner (Fig 228)   The iris is torn away from its ciliary attachment for a variable distance.   On inspection a black biconvex area is seen at the periphery, and the pupillary edge bulges slightly inwards   With the ophthalmoscope mirror a reflex can be obtained through the peripheral gap and the fibres of suspensory ligament and edge of the lens may be visible Uniocular diplopia may be produced by this injury   In

Fig   227 — Lacerations of the pupillary margin of the iris and dislocation of the lens following a blow   (From a drawing by Holmes Spicer)
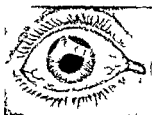
Fig 228 —Iridodialysis following a blow   (After Nettleship)

extensive iridodialysis the detached portion of the iris may be completely rotated, so that the pigmented back of the iris faces forwards (*anteflexion of the iris*)   The iris never becomes re attached, but iridodialysis, apart from other injury, rarely causes serious results   In *traumatic aniridia* or *iridectena* the iris is completely torn away from its ciliary attachment, contracts into a minute ball, and sinks to the bottom of the anterior chamber where it may be impossible to see it   Rarely the same appearance is caused by *total inversion* or *retroflexion* of the iris, the whole iris being doubled back onto the ciliary region out of sight   More commonly inversion is partial, so that the appearance of a coloboma (*q v*) is obtained, but the fibres of the suspensory ligament cannot be seen   In all these cases there is usually hyphaema, and other injuries such as partial dislocation of the lens and so on, may be present

The *treatment* consists in rest and the application of cold compresses. Atropine should be instilled in iridodialysis, but not in ruptures of the iris. If there is also subluxation of the lens neither mydriatic nor miotic should be used.

Ciliary Body. Contusions may cause diminution in the amplitude or loss of accommodation owing to paralysis of the ciliary muscle. The ciliary body may be involved in rupture of the globe (rupture prolapse, &c.), and plastic cyclitis may be induced. Hypotony or low intraocular pressure may follow a blow, probably through interference with the functions of the ciliary body. It may persist for a long time, and be followed by degenerative changes in the lens and shrinking of the globe.

Lens. Subconjunctival *dislocation* of the lens has already been described. The same mechanism which produces the various injuries of the iris may cause the lens to be forced back into the vitreous. The suspensory ligament is then ruptured. The rupture may be complete or partial. When complete the lens may sink to the bottom of the vitreous chamber, where it may be visible as a yellowish mass, occasionally it remains clear and cannot be seen. Partial rupture of the suspensory ligament occurs with subluxation of the lens which may be displaced laterally with or without some degree of rotation. This leads to irregularity in the depth of the anterior chamber which is deeper in the part unsupported by the lens. With the pupil dilated the edge of the lens may be seen as a grey convex line by oblique illumination but more readily and unmistakably as a black line with the ophthalmoscopic mirror (*vide* p. 110). The want of support for the iris causes tremulousness (iridodonesis) on the slightest movement of the eye a tremulousness which is limited to the unsupported part.

Blows upon the eye less directly from before backwards occasionally cause dislocation of the lens into the anterior chamber. It rarely occurs with a lens of normal size, but not infrequently by quite trivial injury when the lens is shrunken. The clear lens in the anterior chamber is not always easily recognised but it does not long remain clear, and diagnosis is then easy. It is more globular than normal owing to its free dom from the restraint of the suspensory ligament. When still clear it looks like a globule of oil in the anterior chamber. With oblique illumination it has a golden rim due to total reflection of the light; this is the exact opposite of the total reflection when the edge of the lens is seen with the mirror, the light being then totally reflected away from the observer's

eye The lens in the anterior chamber causes spasm of the sphincter iridis, which may occur at the moment when it is passing through the pupil Intense iridocyclitis or secondary glaucoma is then set up In most cases of dislocation forwards the lens is shrunken, and the suspensory ligament has become partially absorbed, dislocation into the anterior chamber may occur in these cases spontaneously, without any contusion Unless the lens is very small, extreme irritation is set up by its presence in the anterior chamber, and the eye is lost if it is allowed to remain there

Dislocation of the lens always causes considerable disturbance of vision In partial rupture of the suspensory ligament there is astigmatism which is much increased by tilting of the lens The slackening of the suspensory ligament causes increased curvature and myopia, which may be more than compensated by backward displacement In total dislocation into the vitreous the effect is that of the old cataract operation of couch ing, the pupillary area is aphakic, the refraction is highly hypermetropic, requiring cataract glasses for its correction Vision usually deteriorates gradually

If the lens is displaced so much laterally that the edge crosses the pupil unocular diplopia is present Through the aphakic area of the pupil the eye is highly hypermetropic, through the phakic portion it may be myopic, in addition to which the periphery of the lens acts as a prism Ophthalmo-scopic examination under these conditions shows two images of the disc by the indirect method, differing considerably in size By the direct method the fundus may be observed through the phakic or through the aphakic portion of the pupil, different lenses being required to correct the refraction in the two cases

Subluxation of the lens may occur as a congenital condition (ectopia lentis) (*vide* p 327)

Besides the immediate consequences of dislocation of the lens, very serious remote effects may follow In subluxation the lens is very liable to become opaque, owing to malnutrition The pressure of the edge of the lens on the back of the iris and on the ciliary body often sets up severe iridocyclitis, which *may lead to the loss of the eye, and even endanger the other by* sympathetic ophthalmia (*q v*) Secondary glaucoma is a very frequent sequel (*vide* p 281)

Treatment In the absence of irritation vision may be improved in total luxation into the vitreous and in subluxation by suitable glasses In the latter case it is usually impossible to correct the astigmatism, but sometimes the aphakic part

of the pupil can be used   If iridocyclitis or secondary glaucoma
is present the lens should be extracted if it is possible   It is
imperative when the lens is in the anterior chamber   In all
cases it is unusually difficult   There is always a considerable
rupture of the suspensory ligament, so that vitreous presents
as soon as the corneo scleral section is completed and the
delivery of the lens has usually to be effected with the scoop,
some vitreous being lost (*vide* p 493)   If extraction is impos
sible an iridectomy or trephining may improve matters, but
more usually fails   If the eye is blind and painful it should be
excised   For the treatment of subconjunctival dislocation see
p 534

Besides dislocation of the lens *concussion cataract* occa
sionally follows a contusion   In most of these cases the capsule
is ruptured though the site of rupture, usually behind the
equator cannot be seen clinically   The lens gradually becomes
opaque a rosette shaped opacity being usually first formed in
the posterior cortex (hoby, Fig 236)   Rarely the cataract
remains in this condition, but much more commonly it spreads
throughout the cortex until the appearance of a mature
cataract is found   More or less absorption takes place but it
may be permanently incomplete   The condition should be
treated in the same manner as traumatic cataract

In some cases a circular ring or disc of faint or stippled opacity
is seen on the anterior surface of the lens (Vossius ring) It
usually has about the same diameter as the pupil and has been
attributed to the impress of the iris on the lens produced by the
force of the blow driving the cornea and iris backwards   This
view is supported by the not infrequent presence of iris pigment
on the lens capsule but is opposed by the variation in the size of
the disc and the occasional presence of a second concentric ring
The slit lamp shows that the opacity is due to multitudes of
brown amorphous granules lying on the capsule   It may form in
the absence of hyphæma   Minute discrete subcapsular opacities
may be seen after resorption of the pigment, which takes place
very gradually

Concussion cataract may also be caused by lightning and high
tension electric discharges   It is possible that electrolytic changes
play some part in these cataracts

Vitreous   Hæmorrhage into the vitreous is the commonest
effect produced in it by contusion   The vitreous chamber may
be filled with blood   In this case no reflex will be obtained
with the ophthalmoscopic mirror   With oblique illumination
a dull red hue may be seen especially if the pupil is dilated

The blood may become almost completely absorbed, but cloudy opacities remain In rare cases " retinitis " proliferans follows from organisation of the clot (*vide* p 372)

Liquefaction of the vitreous and opacities in it may follow a blow owing to uveitis and defective nutrition, and without hæmorrhage

Choroid *Rupture of the choroid* occurs as the result of severe contusion It has also been caused by a bullet passing through the orbit behind the eye Immediately after the injury the view is obscured by extravasation of blood When it has become absorbed the rupture, usually not far from the disc and concentric with it, is seen as a curved white streak over which the retinal vessels pass (Plate IX , Fig 2) The retina may also be ruptured, but this is exceptional The edges of the streak are pigmented in the later stages , in the earlier, remnants of blood may be seen The white appearance is due to the sclerotic shining through The rupture is generally to the outer side of the disc, and there are often two or three of different sizes, more or less concentric with each other If the choroid is ruptured near the macula loss of central vision results. If the retina is ruptured also or becomes atrophied throughout its thickness, including the nerve fibre layer, a large sector-shaped scotoma is produced Simple ruptures of the choroid in which the macula is not involved cause little impairment of vision The treatment consists of rest in bed until all extravasated blood is absorbed , atropine and dark glasses, and abstinence from reading, &c

A contusion may cause choroidal hæmorrhage which may be small, shown later by patches of choroido retinal atrophy, or large, subretinal or subchoroidal The latter can seldom be seen ophthalmoscopically, but are part of more extensive mischief

Retina It has already been pointed out that *detachment of the retina* (q v) is often due to contusion *Rupture of the retina* with rupture of the choroid is rare in civil life, but was a common result of explosions during the War *Hæmorrhages* into the retina occur , they are usually small, but large hæmor *rhages into the vitreous (vide supra) are in part derived from* retinal vessels

Commotio retinæ is a frequent result of blows upon the eye Instead of the normal bright red colour the retina shows a milk white cloudiness, usually near the papilla and posterior pole, and over a considerable area It is probably due to œdema It disappears after some days, and vision is usually restored

to normal   In other cases, though vision may be good at first, central vision gradually diminishes, associated with development of pigmentary deposits at the macula (*vide infra*)   Hence prognosis should be guarded in *all* cases of serious blows upon the eye

Serious changes are apt to occur at the macula, and are easily overlooked immediately after the accident, or it may be impossible to obtain a good view   A "hole" may occur at the macula   It appears as a small circular or oval deep red patch, just as if a hole had been punched out   It is caused by cystic degeneration following œdema due to com motio retinæ and in course of time a complete perforation of the retina develops   Similar ophthalmoscopic signs and pathological changes have been observed occasionally after iridocyclitis and associated with arteriosclerosis renal retinitis and amaurotic family idiocy (*vide* p 358)   In other cases the macula looks deeper in colour than normal and in the course of time it becomes pigmented   The spots of pigment are very fine mostly aggregated near the fovea, with a few farther afield   This *pigmentation* is the sign of serious defect in central vision which has a tendency to increase progressively

Optic Nerve   The optic nerve is not infrequently ruptured or injured in fractures of the base of the skull (*vide* p 401) Injuries by sticks or knives &c penetrating the orbit are rare   Avulsion of the optic nerve is very rare in civil practice but occurs in gunshot wounds of the orbit (*vide* p 669)

PERFORATING INJURIES

Perforating injuries may be caused by sharp instruments or by foreign bodies

A *wound with a sharp instrument* may penetrate the cornea the corneo scleral junction or the sclerotic, it may pass in for a variable distance wounding the iris lens, &c , or pass through the eye

Wounds of the Conjunctiva are common   They heal readily, but the process may be hastened   and the resulting adhesion to the sclerotic lessened by introducing one or more sutures Polypoid masses of granulation tissue sometimes form on the surface, they should be snipped off with scissors after application of pantocain

Wounds of the Cornea may be linear or lacerated   The margins swell up and become cloudy through imbibition of fluid   This facilitates closure of the wound and restoration of the anterior chamber   If small and limited to the centre

they heal well unless they become infected   The eye is
irrigated with boric lotion or sterile saline, atropine instilled,
and a pad and bandage applied   A permanent dense opacity
is left, and the contraction of the organising scar tissue causes
irregular astigmatism   If the wound becomes infected it must
be treated like a perforating ulcer

The danger is greatly increased (1) if the wound is large
especially if it extends into the sclerotic, or (2) if the lens is
also wounded   In the former case prolapse of the iris is
almost certain to occur   The prolapsed iris should never be
replaced, even if this is possible, since
it may carry infection into the eye   It
must be excised (*vide* p 212), care being
taken that the iris is quite free, though
this is a counsel of perfection not always
to be attained   Freeing of the iris is
specially difficult with quasi tangential
wounds (*vide* Fig 237 to the right)   In
such cases it is a good plan, if there is
an anterior chamber, first to make a
small keratome incision in the cornea
on the opposite side to the wound,
3 mm inside the limbus (Fig 229)
After the prolapse has been excised in
the usual manner a repositor can be
passed through this incision and swept
over the surface of the iris (Goulden)
This device is useful for freeing the
iris from punctured wounds near the
limbus, in which incarceration occurs,
but is so small as to make excision
through the original wound impossible   In some cases it
is advisable to cover the wound with a conjunctival flap
(*vide* p 211)   Atropine should always be instilled (never
eserine)

Fig 237
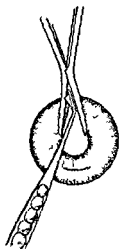
If in a few days it is found that there is an anterior synechia
this should usually be divided as soon as the wound is suffi-
ciently healed to permit of the necessary procedures without
re opening it   If this is not done the traction on the iris will
keep up irritation in the eye, as shown by ciliary injection, &c ,
and such eyes are liable to cause sympathetic ophthalmia
Moreover, a broad anterior synechia tends to bring about
secondary glaucoma, or predispose to secondary infection and
panophthalmitis

Wound of the lens very greatly increases the gravity of the case, especially in children It may escape notice at first, especially if the wound is small, *e g* , that caused by a needle or thorn The lens swells and keeps the iris in contact with the cornea, so that re formation of the anterior chamber is much delayed If at length it re forms the aqueous becomes filled with swollen lens fibres, which also irritate the iris The swelling is greater and more rapid the younger the patient Infection, which is one of the greatest dangers of all perforat ing wounds, is particularly likely to occur in these cases The excision of any prolapsed iris in such a manner as to free it completely from the wound is extremely difficult The subse quent prolonged contact of the iris with the cornea facilitates
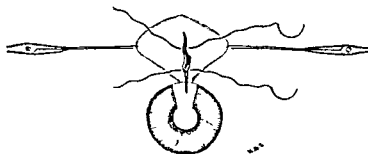
Fig 230

the formation of broad adhesions of iris and often also of lens capsule which it may be found impossible to divide, or which, if divided, quickly re-form Ciliary injection is kept up, and sympathetic ophthalmia is very liable to supervene if the eye is retained too long

Occasionally in perforating wounds with a dirty implement pyogenic organisms are carried into the eye, multiply there and cause rapid necrosis of the whole cornea In these cases a ring of deep infiltration appears in the cornea 2 or 3 mm internal to and concentric with the corneo-scleral margin— so-called *ring abscess* There is much chemosis of the con junctiva and a greenish discharge The organism has gener ally been found to be the bacillus pyocyaneus Usually panoph thalmitis is set up and the whole of the central part of the cornea is cast off The only chance of saving such an eye is to do a paracentesis directly the infiltration is observed and to

wash out the anterior chamber with hydrogen peroxide. Sulphonamide treatment (*vide* p. 693) should be used.

Wounds of the corneo-sclera are particularly liable to set up sympathetic ophthalmia (*q.v.*). In them the ciliary body is injured directly, and may be prolapsed. There is the usual danger of infection, and if it occurs panophthalmitis is certain to follow on account of the ready communication with the vitreous. If this does not happen ciliary irritation is kept up. If suppuration occurs there is little hope of saving a useful eye, but there is little or no danger of sympathetic ophthalmitis.
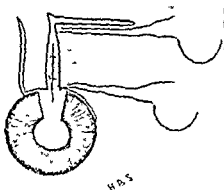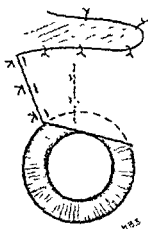
Fig. 231.   Fig 232

If the lens is wounded the chances of saving the eye are greatly diminished.

Treatment. An attempt should be made to save the eye. The orbicularis oculi is paralysed by injection of novocain into the branches of the facial nerve as they cross the malar bone (*vide* p. 466, Fig 242). The infiltration is carried to the infraorbital foramen and up to the temporal extremity of the eyebrow. Pantocain (1 per cent.) is instilled into the conjunctival sac, 1 c.c. of novocain (4 per cent) into the region of the ciliary ganglion, and 1 c c into Tenon's capsule posterior to the site of the wound. The eye is irrigated with 1 in 10,000 oxycyanide of mercury lotion, and a speculum inserted. The wound should be freely exposed as in Fig. 230, and ragged tags of conjunctiva trimmed. Sutures are passed through the edges of the conjunctival wound, held in mosquito pressure

forceps and retracted   The edges of the scleral wound are
gently carbolised and sutures inserted by an eyeless corneo-
scleral needle (Fig 231)   The sutures are looped ready to tie
Any prolapsed iris and ciliary body is drawn out of the wound
and abscised   The scleral sutures are tied immediately so

Fig 231

Fig 234

as to minimise loss of vitreous   Figs 231 and 232 show
diagrammatically the conjunctival flaps fashioned so as to
cover the wound and thereby diminish the risk of exogenous
infection   Atropine is instilled the eye bandaged lightly, and
the patient put to bed   Wounds involving the sclera on both

Fig 23.)

sides (Fig 233) are specially difficult to deal with   Before
excision of the prolapse the conjunctiva is freed at the limbus
(Fig 234) and afterwards drawn over the wound by stitches
inserted as in Fig 235   Such a flap supports the cornea and
helps to bring the edges of the wound in apposition at the
same time assisting to protect the eye from intraocular
infection

If the eye does not quiet down in the course of a week or

ten days, as shown by diminution of ciliary injection and cessation of photophobia and lacrymation, it should be excised In the interval the cornea is examined most carefully each day by oblique illumination with the loupe for precipitates ("k p") If they are seen the eye should be excised Similar care is devoted to the discovery of spots of "k p" in the other eye, and if they should be found there excision of the injured eye is still more imperative at the earliest possible moment If the eye quiets down quickly and there is no evidence of iridocyclitis in either eye the case will probably do well, but it should be kept under observation for a prolonged period (*vide* p 459)

If there is much prolapse of vitreous as well as of iris and ciliary body, or if the lens is wounded, there is little probability of saving the eye If it is almost certain that useful vision will be lost the risks of sympathetic should not be run, but the eye should be promptly excised

Wounds of the sclerotic are not always easily recognised The eye may have been wounded through the lid The bruising and laceration of the lid may make examination of the eye difficult The lid should be raised from the globe and drawn back with a Desmarres' retractor, under local anæsthesia Even when the eye is examined the effusion of blood under the conjunctiva may render the diagnosis uncertain still more the question of perfora tion When perforation has occurred, there is reduction in the intraocular tension If the perforation is near the cornea,

Fig 236 —Traumatic posterior cortical cataract (Koby)

the anterior chamber is shallow or obliterated If the wound is large, prolapse of some of the contents of the globe occurs The uvea—iris, ciliary body, or choroid—are most easily recognised on account of their pigmentation Very often the gelatinous vitreous can be seen hanging out of the wound Hyphæma and vitreous hæmorrhage may be present with or without perforation

Treatment If the injury is so severe that there is no likeli hood of recovery of useful vision, the eye should be excised If there is a chance of useful vision, or if permission to excise

is withheld, the sclerotic may be sutured and the sutures tied after excision of prolapsed vitreous, &c Very small wounds do not require suturing but the conjunctiva should be cleansed and stitched over them Atropine should be instilled, and both eyes bandaged Complete rest in bed is imperative Such eyes usually shrink, unless indeed panophthalmitis ensues

Wounds of the lens cause traumatic cataract Usually the anterior capsule is wounded , when the posterior capsule is torn the lymph in the vitreous acts in the same manner as the aqueous A few hours after the injury the lens becomes cloudy in the vicinity of the wound owing to the action of the aqueous upon the fibres causing them to swell In most cases opacities rapidly form in the posterior cortex, irrespective of the exact site of the wound They are at first feathery lines which follow the natural distribution of the lens fibres Later a rosette-like opacity is formed which gradually spreads until the whole cortex is opaque (Fig 236) Flocculent grey masses protrude through the opening in the capsule, some of which become free and sink to the bottom of the anterior chamber Sometimes the whole chamber is full of white flocculi, and the lens nucleus may escape entire The masses are gradually dissolved by the aqueous, and pass out with it through the angle of the chamber In this manner, in young patients the whole lens, with the exception of the capsule, may be absorbed Usually absorption ceases earlier through closure of the capsular wound The enclosed lens fibres become opaque and discission is necessary to cause their complete absorption , in adults, with a hard nucleus extraction may be necessary (*vide* p 486) The smaller the wound in the capsule, the sooner it is likely to close In rare cases, with very small, though it may be deep, wounds, the opacity may remain limited to the site of injury, especially if the wound is quickly sealed up by a posterior synechia

A certain amount of inflammatory reaction with ciliary injection is always set up, which may be excessive, even in the absence of infection It will then be found that the intra ocular tension is raised The swelling of the lens forces the periphery of the iris against the cornea and secondary glaucoma supervenes This tendency is increased by the difficulty with which the highly albuminous aqueous escapes from the eye, especially if the wound in the capsule is large and much of the lens substance has escaped into the anterior chamber If the secondary glaucoma is not relieved the sight will be lost by destruction of the optic nerve The aqueous and swollen lens

substance must therefore be let out by a curette evacuation (*vide* p 484)

Traumatic cataract is deliberately induced in the operation of discission

In the absence of secondary glaucoma, the condition is treated by rest in bed, atropine, and a bandage It is of the utmost importance that the pupil should be kept well dilated If it is not, adhesions will form between the iris and the lens capsule The tendency to iritis is increased, a ring synechia may form, leading to a more serious form of secondary glaucoma, and in any case a subsequent needling will be made more difficult and dangerous *Sterile* atropine ointment, 1 per cent , should be used three or four times daily If the pupil does not dilate satisfactorily, hot bathings should be given every four hours, and in the case of adults leeches may be applied It is usually necessary to needle the lens capsule in order to obtain an opening through which vision is made possible, and needling may have to be repeated (*cf* Lamellar Cataract)

Perforating wounds with retention of foreign bodies have special features and dangers Eyes containing foreign bodies are particularly liable to set up sympathetic ophthalmia In cases of perforating wound, the question often arises whether a foreign body has been retained within the eye The foreign bodies most likely to penetrate the eye and be retained are minute chips of steel, stone, and particles of glass, lead pellets, copper percussion caps, less frequently spicules of wood In chipping stone with an iron chisel, it is usually a chip of the chisel and not of the stone which enters the eye Among war injuries penetration of the eye by fragments of the casing of rifle bullets, often containing nickel, of shells, &c , frequently occurs

The *size and velocity* of the missile are of importance If the foreign body is large so much damage is usually caused that the eye has to be removed Very minute particles can, however, penetrate the cornea or sclerotic and lodge in the deeper parts of the eye The velocity of these small particles must be very high, for the energy needed to penetrate the walls of the globe is considerable, and the relationship of energy to mass and velocity is given by the formula $E = \frac{1}{2} m v^2$ This is a point of more than academic interest It has been shown that rifle bullets are sterilised by their rapid transit through the air This fact may account to some extent for the sterility of minute intraocular foreign bodies, though not entirely , for they are not always sterile, and

when they are it is often more probably due to being hot when
emitted   Their irregularity of shape would render them less
easily sterilised   *Cæteris paribus* metallic foreign bodies
appear to be more commonly sterile than those made of other
substances

The *nature of the foreign body* is very various and affects
the diagnosis, pathological condition treatment, and prog
nosis profoundly   As regards diagnosis it is only rarely that
we can see the foreign body in the eye or have indubitable
proof of retention   In the absence of irrefragable evidence
our surest test is skiagraphy, but this method has severe
limitations   Relatively few substances are opaque to X rays
Fortunately by far the greatest number of intraocular foreign
bodies are composed of iron or steel which give a good
shadow   The same applies to lead and metallic fragments
from the casing of rifle bullets   Particles of glass often fail
to reveal their presence in the skiagram except heavy
lead glass, of which some bottles are made   Very accurate
localisation is necessary   Various methods are in use,
Mackenzie Davidson s method is usually employed in England
Sweet s method   dependent upon the same principle in
America   When it is remembered that accuracy of localisa
tion of the order of 1 mm is essential and that inaccuracy of
this amount may lead to the needless sacrifice of an eye it
will be recognised how culpable is any carelessness in this
respect

The influence of the nature of the foreign body on the
pathological condition set up in the eye is profound and varied
Thus it was shown by Leber many years ago that copper
causes suppuration even in the absence of pyogenic organisms
leucocytosis being set up by chemical action   Clinically,
however, this result may certainly be delayed for a very
considerable period possibly owing to the copper—usually a
fragment of a percussion cap—being surrounded by a wall of
inflammatory material and encysted

Copper in the lens may cause little reaction   This is
further evidence in favour of the usual reaction being chemical,
for such changes are very slow in the lens   Another fact
supporting this explanation is that even in severe suppuration
induced by copper within the eye the inflammation tends
to cause shrinkage of the globe and not perforation   Not
infrequently, however the reaction is so severe as to cause
expulsion of the foreign body from the eye   The pus forma
tion retrogrades after a time and is not progressive   Only

very rarely does a copper particle become encapsuled with restoration of useful vision Sympathetic ophthalmia is less likely to follow copper foreign bodies than others, probably owing to the intense reaction (Leber)

Iron is also dissolved by the tissue fluids and sets up the condition known as *siderosis bulbi* The earliest clinical manifestation is the deposit of iron in the anterior capsular cells of the lens These are not affected uniformly, but oval patches of the rusty deposit are arranged radially in a ring corresponding with the edge of the dilated pupil This appearance is pathognomonic At later stages the iris becomes characteristically stained, first greenish and later reddish brown The vision of these eyes, however little affected by the primary injury, gradually fails owing to degenerative changes in the retina and lens

Siderosis bulbi (Bunge) has been exhaustively investigated In a typical case brown granules are found in the corneal cor puscles, in the meshes of the ligamentum pectinatum iridis on the inner surface of the ciliary body, and in the retina The anterior layers of the iris are impregnated, and in addition to subcapsular deposits in the lens, the fibres are also stained The retina shows complete degeneration, and Perls' micro chemical reaction shows the whole retinal vascular system marked out by blue coloration There is always intense blue coloration imme diately around the foreign body The pigment epithelium of the ciliary processes, para ciliaris retinæ, and retina, and sometimes the supporting tissues of the retina, show diffuse staining The brown pigmented cells which give the blue reaction are found particularly in the angle of the anterior chamber and in the retina, less in the iris, and least in the choroid They are not bleached by the ordinary methods for bleaching the normal pigment Hæmorrhage associated with the injury introduces a complication, for it causes hæmatogenous pigmentation giving the iron reaction and distinguished with difficulty from the xenogenous pigmenta tion due to the foreign body

The chemistry of siderosis bulbi is not yet fully understood E von Hippel says that the iron is dissolved by the carbon dioxide of the tissues and is fixed by cells which have a specific affinity for the metal, it then becomes oxidised It has also been suggested that the iron is dissolved by acid phosphates in the intraocular fluid, or that iron may enter into solution in organic form as an albuminate or in combination with an organic acid The brown precipitate in the tissues is almost certainly produced by oxidation, but it is not a simple oxide or hydroxide as it is only very slightly soluble in oxalic acid (McMullen)

The characteristic ring of brown spots under the lens capsule is caused by deposition of iron in circumscribed aggregations of newly proliferated capsular epithelial cells Leber showed experimentally that the introduction of a particle of iron into the vitreous causes extreme degeneration of the retina Peculiar large granular cells are found which are derived for the most part from the retinal pigment epithelium

Metals, other than iron and copper—such as lead, zinc, gold, silver—appear to cause little chemical reaction and usually remain quiescent, becoming more or less thoroughly encapsuled according to their position Lead becomes coated with the carbonate

Stone is chiefly dangerous from pyogenic infection, but chemical changes also occur, varying with the nature of the stone

Glass and porcelain may cause remarkably little reaction, but iridocyclitis and disorganisation of the eye usually occur eventually

With regard to wood, apart from infection, the most characteristic feature is the local irritation produced, resulting in the formation of dense granulation tissue, studded with so-called foreign body giant cells

Eyelashes may be carried into the anterior chamber in perforating wounds of the cornea, whether accidental or operative, and caterpillar hairs may penetrate the globe (vide p 187)

More important numerically than the chemical changes are those due to infection, and though these are not, strictly speaking, due to the nature of the foreign body, it is undoubtedly true that certain types of foreign body are more apt to give rise to suppuration than others Much may be learnt in this connection from the analogy of hypopyon ulcer The common hypopyon ulcer is due to pure or mixed infection with pneumococci and it is notorious that it is more likely to be caused by fragments of stone, wounds with the leaves of plants or twigs of trees and so on, than by steel or other foreign bodies Moreover, it admirably exemplifies the *rôle* played in such infections by the resistance of the tissues, for the patients are usually either old and debilitated or alcoholic With regard to intraocular infections, it is to be borne in mind that the lens substance and the vitreous form excellent culture media, and further, that even saprophytic organisms, like bacillus subtilis, are capable of setting up a suppurative inflammation in the eye Probably the com

monest pyogenic organism in the interior of the eye is, however, the pneumococcus

The foreign body may pass through the cornea or the sclerotic   The wound of entry may be extremely minute   The patient may even be unaware that a foreign body has penetrated the eye   If it has passed through the cornea, the minute wound or scar can always be found by careful examination with oblique illumination and a loupe   It may escape detection in the sclerotic

The foreign body may be retained in the anterior chamber   Here it may fall to the bottom of the chamber, and if very small be hidden by the sclerotic   It is generally, however, caught in the iris, and can be recognised with a loupe   A piece of glass in the anterior chamber is exceptionally difficult to see, on account of its refractive index differing so little from that of the surrounding media

The foreign body may pass into or through the lens, either by way of the iris or of the pupil   In each case a traumatic cataract is produced, which undergoes the usual changes (*vide* p 446)   If the particle has passed through the iris there will be a hole in this structure   If the case is seen very early or very late, the hole looks black by oblique illumination, but shows a red reflex when illuminated by the ophthalmoscopic mirror   In the intermediate stage the cataractous lens behind the hole prevents a red reflex from being seen   A hole in the iris is of great diagnostic significance, since it rarely occurs except as the result of perforation by a foreign body   The foreign body may be visible in the lens   either before or after dilatation of the pupil   It is possible for a foreign body to pass through the iris and through the circumlental space without wounding the lens

The foreign body may be retained in the vitreous   Access to the vitreous by the foreign body may be given by various routes   through the cornea, pupil and lens , through the cornea, iris and lens , through the cornea   iris and zonule , or through the sclerotic   Hildebrand found these four routes represented in forty three cases by 6, 16, 6, and 15 respectively   The particle may pass quite through the globe into the orbit, remain near the site of entry, become imbedded in the opposite wall, rebound from it, or be suspended in the vitreous   In the latter case it eventually sinks to the bottom of the vitreous chamber owing to degenerative changes in the humour, which lead to liquefaction, partial or complete   Sometimes air is carried in and appears as bubbles in the

vitreous, these rapidly become absorbed If the particle is small, the lens clear, and there has been little hæmorrhage the body may be seen ophthalmoscopically in the vitreous or retina The track through the vitreous looks like a grey line The foreign body, generally black, and often with a metallic lustre, is surrounded by white exudate and red blood-clot If the particle has been long *in situ* it may become more or less encapsuled, a small white areas of fibrous tissue being seen with dense masses of black pigment in and around it Fine pig mentary disturbance at the macula may follow, irrespective of actual injury to this region, and indeed merely as the result of concussion More extensive degenerative processes also occur in the retina, which may become detached Encapsula tion is often rapid with iron, and useful vision may persist for an indefinite time Particles more than 1—2 mm in size are almost certain to lead to the destruction of the eye In the absence of sepsis siderosis bulbi is the almost inevitable cause of destruction An encapsuled foreign body may become free after a long period of quiescence The encapsulation of foreign bodies in the retina depends largely upon their asepsis The amount of cicatricial tissue formed in the early stages is inversely proportional to the amount of necrosis which depends chiefly upon bacterial invasion though mechanical injury and chemical action must also be taken into account

Retinal degeneration attacks the macula or is generalised In the former group yellowish white spots appear in the region of the fovea and pigmentation may also occur Serious disturbance of vision results, and is not recovered from Generalised retinal degeneration takes the form of pigmenta tion, resembling that of retinitis pigmentosa, and may be preceded by night blindness

The prognosis is always bad It is least bad if the foreign body is in the anterior chamber and the lens is not wounded The eye may be saved if it is in the lens, especially in young people, whose lenses are capable of becoming completely absorbed The prognosis is far better when the lens is not wounded and this is still more markedly the case the younger the patient With a small foreign body the wound of entry is so small that prolapse of iris rarely occurs, but if the lens is wounded, and more particularly if the patient is young, so that the swelling of the lens is excessive, the iris is pressed forwards against the cornea, anterior synechia is readily formed, and the obliteration of the angle of the anterior chamber easily leads to secondary glaucoma If the iris is

incarcerated in the wound in these cases the division of the synechia presents considerable technical difficulties, the iris and ciliary body are kept in a state of irritation, and the dangers of sympathetic ophthalmia are greatly enhanced The satisfactory evacuation of the lens substance is much more difficult than in ordinary discission of the lens, so that the continued apposition of the wounded and inflamed iris to the cornea is scarcely to be avoided Moreover, in my opinion, children are very decidedly more susceptible to sympathetic ophthalmia than adults

Though the dangers of wound of the lens are diminished in older patients, there is no doubt that the prognosis is rendered graver by this complication However satisfactory the result may be from the purely surgical point of view, an aphakic eye
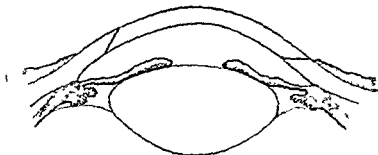
FIG 237

is decidedly less useful than one which retains a normal lens

Treatment It is a rule that the foreign body should be removed There are rare exceptions to this rule, more particularly if (1) the foreign body was probably sterile, (2) little damage has been done to vision ; and (3) the process of removal will almost inevitably destroy sight These conditions are most often fulfilled in the case of minute foreign bodies in the retina

Magnetisable foreign bodies are more easily removed than others, since the small or the large electro magnet can be brought to bear upon them

A chip of steel free in the anterior chamber is removed in the following manner by the hand magnet (Fig 238) Retro ocular anæsthesia or intravenous pentothal sodium should be used owing to the iritis already present After

washing out the eye a keratome incision is made above,
3 mm from the limbus The keratome is pushed straight on
until the incision is of the required size, remembering that
the internal wound in the cornea is smaller than the external
The keratome is removed moderately quickly but smoothly,
so as to prevent loss of aqueous The pole of the small magnet
is then placed over the foreign body outside the cornea and
moved towards the wound thus dragging the particle along
the back of the cornea The posterior lip of the wound is
then depressed with the pole and the foreign body is drawn
towards it out of the wound If much aqueous is lost it is
more likely to become entangled in the iris and considerable
difficulty may be experienced in freeing it It is wise to wait
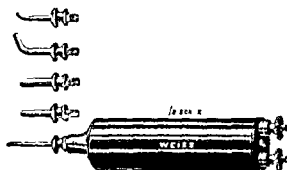
Fig 238 —Small magnet with poles of various shapes.

20 minutes for the anterior chamber to re-form before removing
the foreign body and it may be necessary to pass a flat pole
into the chamber All the preparations for dealing with a
prolapse of iris must be made (*vide* p 212)

A foreign body on the iris may sometimes be removed
with iris forceps through a similar incision If it is entangled
in the iris tissue, the iris must be drawn out of the wound
and the part containing the foreign body excised with
de Wecker's scissors, as in the operation for iridectomy
(*vide* p 470)

If a non magnetic foreign body lies on the iris in the angle
of the anterior chamber it is impossible to get at it with
forceps by an ordinary keratome incision immediately over
it, such as the corneal incision to the right in Fig 237 The
incision should be made at 3 mm inside the limbus in the quad
rant of the cornea lying over the foreign body the point of

the keratome being directed straight at the foreign body (Fig 237 to the left) The foreign body can then be lifted out with toothless forceps, and the risk of prolapse of iris is also minimised (Goulden)

If the foreign body is in the lens, a few days should be allowed to elapse for the aqueous to act upon the lens fibres A curette evacuation (*vide* p 484) is then performed and the foreign body will probably be evacuated with the lens matter, or it may be removed by forceps, or if magnetisable, by the small magnet In a young subject it may be advisable to increase the opening in the capsule by discission a few days before doing a curette evacuation In these cases a subsequent needling will often be required to obtain a clear opening in the pupillary area of the capsule It should be done in exactly the same manner as after discission for lamellar cataract If the patient's other eye is normal he will not be able to wear the correcting glass for the aphakic eye, but his field of vision will be increased on this side A more cogent reason for operating is found in the fact that it is easier to obtain a clear opening at this period than after months or years, when the capsule will have become thickened and very difficult to divide In elderly patients it may be necessary to extract the lens by the operation for extraction of senile cataract (*vide* p 486), but the large amount of soft lens matter will increase the dangers of the operation

If the foreign body is in the vitreous or retina it is practically impossible to remove it without very seriously damaging the eye unless it is magnetisable The treatment then lies between leaving it alone and watching the case, or excising the eye on account of the damage done or the danger of sympathetic

If the substance is iron it may be possible to remove it with the large magnet (Haab's Giant Magnet or Mellinger's Ring Magnet) This will be facilitated by knowing its position either by direct observation or by skiagraphy , some hint may be obtained from the position of the wound of entry and the probable direction in which the foreign body was travelling If the patient is seen immediately after the accident it is best to use the large magnet at once, without waiting for a skiagram The longer the foreign body is left the more firmly it becomes imbedded in exudates or fibrous tissue, and the less the probability of its successful removal

The patient, whose pupil should be fully dilated, is seated in front of the magnet if Haab's instrument is used (Fig 239)

The eye is brought close to the magnet, the cornea touching the pole This is important since if there is a large piece of iron in the eye and the cornea is not in contact with the pole the whole eye may be drawn forward out of the socket when the current is turned on   Moreover, the direction of the core of the magnet should coincide as nearly as possible with the direction of entry of the foreign body The current is then turned on   some pain is usually felt when a piece of

Fig 239 —Removal of intraocular fore gn body by Haab magnet first stage Drawing the foreign body into the po terior chamber the eye looking forwards   (Goulden & Whiting)

Fig 240 —Removal of intraocular fore gn body by Haab magnet second stage Drawing the fore gn body across the posterior chamber from behind the iris (Goulden & Whiting)

steel is present within the eye If the operation is successful the foreign body comes forward into the posterior chamber It may be necessary to turn the current on and off several times before this happens If the particle is small and deeply imbedded the operation is likely to fail, hence it should be performed as soon as possible after the injury, before the chip has become firmly encapsuled or imbedded in exudates   The foreign body generally passes round the lens not through it It will be seen bulging the iris forwards   The current should then be turned off and the eye adjusted so that the

particle will be drawn towards the pupil (Fig 240) When it has fallen into the anterior chamber the patient is transferred to the operating table and the foreign body removed with the small magnet in the manner already described

In some cases when the foreign body has been accurately localised and the large magnet has failed to bring it forward it can be removed by the small magnet introduced through a scleral incision made by surgical diathermy as nearly as possible over the site.

The immediate effect of extraction of foreign bodies with the large magnet is often good, but irreparable damage is often done to the eye   The tracks through the vitreous often become filled with fibrous tissue   As this organises and contracts the retina is pulled up, and total detachment destroys vision   Or more severe iridocyclitis may be set up and the eye shrinks

The ring magnet has the advantage that the patient lies upon the operating table throughout   When a current passes round a solenoid a magnetic field is generated, its greatest saturation being in the central axis of the solenoid   The ring is placed over the patient's head, which is arranged so that the affected eye is as near the centre as possible   When the current is turned on every steel instrument placed within the ring becomes a magnet the force varying with the mass of metal in the instrument and its position in the ring   The foreign body is drawn forwards as already described, by means of rods of soft iron of various sizes The smallest should be used first and the largest should be firmly grasped, otherwise they will be dragged out of the hand and thus do damage   As soon as the foreign body is seen to bulge the iris forwards the position of the rod is altered so as to draw it through the pupil   It may then be withdrawn by the small magnet or a keratome incision can be made, and the smallest rod or a steel spatula can be used in the same manner as the hand magnet

PANOPHTHALMITIS

Panophthalmitis is generally caused by infected wounds whether accidental or the result of operations, and ulcers   Less *frequently it is metastatic, accompanying pyæmia and puer-*peral fever, meningitis, and orbital cellulitis (*vide* p 341)   In the exogenous form the vitreous is usually first affected, organisms grow in it as in a culture medium, and purulent cyclitis, retinitis, and choroiditis are set up (Fig 241)   In most cases the deeper parts of the vitreous are infected   In simple prolapse through a scleral wound the vitreous offers

remarkable resistance to infection (W. A. Gray). In the endogenous forms there may be a septic embolism of a retinal artery or the choroid may be first affected. In this group it may be bilateral.

In both forms there is rise of temperature, headache, drowsiness, and sometimes vomiting. In the exogenous forms the edges of the wound become yellow and necrotic, hypopyon appears, there is great chemosis, with intense ciliary and conjunctival congestion, and the lids are swollen and red. There
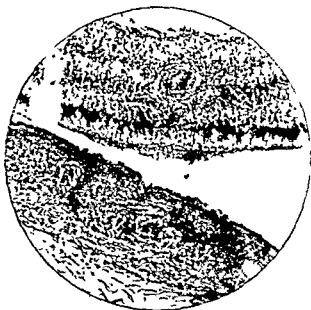
FIG. 241.—Section of the retina and choroid in panophthalmitis (× 60), following a perforating wound

is severe pain in the eye, due at first to iritis, later to increased tension. The vitreous becomes purulent, as shown by a yellow reflex by oblique illumination. The anterior chamber soon becomes full of pus, and the cornea cloudy and yellow; ring infiltration may occur (*vide* p. 442). There may be exophthalmos and limitation of movement of the globe, due to extension of the inflammation to Tenon's capsule. In the metastatic cases rapid failure of vision, a yellow reflex, and hypopyon are found in the early stages.

If the case is left to take its course the pus bursts through,

usually just behind the limbus The pain subsides and after prolonged suppuration the eyeball shrinks

The prognosis is bad, the eye being almost invariably lost   The condition is not likely to set up sympathetic ophthalmia

The pneumococcus is responsible for most cases of panophthalmitis but it is also caused by staphylococci, streptococci, bacillus coli, bacillus pyocyaneus (*vide* p 442), and even by saprophytic organisms such as bacillus subtilis

Treatment   In the early stages after operation wounds an attempt must be made to stay the process   The edges of the wound are cauterised with pure carbolic acid or the actual cautery   The anterior chamber may be washed out with hydrogen peroxide solution, and iodoform introduced   Hot bathings, medical diathermy and leeches are applied and atropine instilled   Sulphonamides should be given in full doses (*vide* p 693)

As soon as it is evident that the eye cannot be saved it should be excised   This should not be left too long and great care should be taken that no undue pressure is put upon the eye   If pus escapes there is danger of purulent meningitis being set up, the patient's life being thereby endangered   If there is any risk of this occurring the globe should be eviscerated by excising the cornea and scooping out all the intraocular contents special care being taken to leave no uveal tissue behind   The interior of the sclerotic is then swabbed out with perchloride lotion (1 in 2 000) and the conjunctival sac irrigated with a large quantity of weaker lotion (1 in 5,000) Most of the sclerotic may be excised, but a collar of it should be left around the optic nerve

SYMPATHETIC OPHTHALMIA

Sympathetic ophthalmia (or sympathetic ophthalmitis) is the much dreaded condition in which serious inflammation attacks the sound eye after injury of the other eye   In recent years sympathetic ophthalmia has become a rare disease in spite of the fact that ophthalmic surgery has become more conservative   Though common in the American Civil and Franco Prussian Wars it was very rare during the Great War This gratifying fact is due to increased skill in the treatment of perforating wounds, particularly in the application of antiseptic principles. A perforating wound, especially if a foreign body is retained within the eye is, however, a source of great anxiety to the most experienced surgeon

Sympathetic ophthalmia almost always results from a perforating wound, especially such as is caused by a foreign body which remains within the eye   Wounds in the ciliary region—the so-called " dangerous zone "—involving the ciliary body and leading to its incarceration in the scar, have always been considered specially dangerous , it is doubtful if, *per se*, they are more dangerous than others   On the other hand, it is certain that wounds in which iris, ciliary body or lens capsule is incarcerated are more likely to set up sympathetic ophthalmia than others   If suppuration supervenes sympathetic ophthalmia is very unlikely to follow, hence perforating ulcers very rarely cause it   It is also extremely rare without perforation if indeed it ever occurs in these circumstances

Children are particularly susceptible, but it occurs at any age   It usually begins four to eight weeks after the injury to the first eye (the exciting eye) has taken place, rarely earlier, but the onset may be delayed for many months or even years —it is said as many as 40 years

There is always iridocyclitis in the exciting eye   Usually it is a plastic iridocyclitis which has been set up by injury and has not subsided in the course of three or four weeks   Instead of quieting down the ciliary injection remains, there is lacrymation and the eye is tender   special attention should be directed to the presence or absence of precipitates (" k p ") on the back of the cornea   In the rarer cases of delayed sympathetic ophthalmia the exciting eye has passed into a quiescent state   It may have shrunken completely   The onset of sympathetic ophthalmia in the second eye is then often ushered in by return of irritation—ciliary injection, tenderness, &c—in the shrunken globe   The exciting eye, while showing evident traces of old iridocyclitis, may yet possess useful vision

Sympathetic ophthalmia—the disease in the second or sympathising eye—is almost always a plastic iridocyclitis differing in no respect from this form of iridocyclitis due to other causes   In rare cases it manifests itself as a neuro retinitis or choroiditis   In cases which the surgeon knows to be liable to the condition the first sign may be the presence of precipitates (' k p ") on the back of the cornea, noticed at this early stage because they have been dreaded and carefully watched for   In other cases the patient first seeks advice for defective vision or inflammation in the uninjured eye (sympathetic irritation)

Prodromal symptoms are sensitiveness to light and transient

indistinctness of objects The latter is due to weakness of accommodation , objects become blurred when doing fine work, but after an interval of rest vision improves   On examination at this stage there may be lacrymation, slight ciliary injection, tenderness of the eyeball, as shown by the patient shrinking from an attempt at examination, precipitates on the back of the cornea, and vitreous opacities   The prodromal symptoms may occur in intermittent attacks, spread over a considerable period

When fully developed all the signs and symptoms of irido cyclitis (*q v*) are present, varying in degree according to the severity of the case   The prognosis as to vision is always doubtful, but if there is much deposition of plastic exudates in the pupillary area it becomes extremely grave   Cases show ing little exudation (" serous iritis "), but a deep anterior chamber and " k p ," have a more favourable prognosis, but they may at any moment develop into the severe plastic type   Tension, difficult to determine on account of tenderness, is moderately raised in the early stages   It may then pass into the condition of lowered tension with gradual shrinking of the globe , or the iridocyclitis may subside, the eye quieting down and retaining fair vision   In the worst cases a ring synechia forms and secondary glaucoma supervenes (*vide* p 281), or both occlusio and seclusio pupillæ or total posterior synechia (*vide* p 259) occur and the eye shrinks   Sympathetic ophthal mia sometimes takes two or more years to run its course

The *pathology* of sympathetic ophthalmia is unknown.   The microscopic features in both the exciting and the sympathising eye are the same   In the earliest stages examined there are nodular aggregations of small round cells scattered throughout the uveal tract   In later stages the infiltration becomes diffuse, and epithelioid and giant cells appear , in fact, the condition is scarcely distinguishable from tubercle of the uveal tract. These are merely the signs of reaction to a constant, relatively mild form of irritation, and the view that the disease is tuber culous (Meller) is improbable   The ordinary signs of uveitis and its consequences are present

The evidence which has accumulated in modern times tends *to show that sympathetic ophthalmia is an infective disease* It is least liable to occur in otherwise likely cases if the wound or the retained foreign body is sterile   On the other hand, it very rarely occurs if actual suppuration has taken place in the exciting eye , possibly this may be due to some specific organism being destroyed by the superabundant growth of pyogenic organisms   It is more likely to occur from retention

of shot, a chip of stone, glass china, &c , than from that of a particle of hot steel, probably because the latter is sterile

Sterility of an ocular wound is usually judged by a satisfac tory course of healing and the absence of suppuration   It is by no means certain that all such wounds are, strictly speaking sterile   The resistance of the patient's tissues has to be taken into account   With the same precautions a cataract wound may heal readily in a healthy man, but only after prolonged subacute iridocyclitis in a weakly patient   In many of these cases there are reasons for delayed cicatrisation such as incarceration of the iris synechia of lens capsule &c , but the exact mode in which they act is a matter of conjecture

Various theories have been brought forward to explain the occurrence of inflammation in the sympathising eye   It has been suggested that severe inflammation in one eye produces a tendency to ciliary irritation in the other eye by some occult means connected with their anatomical and physiological symmetry , there is no evidence to support this conjecture More probable, *a priori*, is the view that infection travels along the optic nerve *via* the chiasma   On this theory one would anticipate neuro-retinitis in the sympathising eye as the most frequent manifestation of the disease   but it is extremely rare The experiments supporting this theory fail to substantiate it The most probable theory is that there is a specific organism or virus which has as yet escaped observation, possibly because it is ultra visible by the microscope, but one which causes general infection through the blood stream   It may be that in addition to the infection there is an allergic factor, since it has been shown that uveal pigment can act as an antigen   It may be conjectured that the organism is harmless to other organs of the body, and that it finds a suitable nidus only in the other eye   perhaps owing to allergic hyper sensitivity of the uveal tract   This theory explains best the facts of both ordinary and anomalous cases   When sympa thetic ophthalmia supervenes after the injured eye has long been shrunken it may be conjectured that the organism has lain quiescent and encapsuled   The fact that in such cases the shrunken eye is again injured or becomes spontaneously irritable and inflamed shortly before the outbreak of inflamma tion in the other eye lends colour to this view   Cases in which the injured eye is excised and sympathetic ophthalmia is said to supervene many years afterwards are best explained as ordinary iridocyclitis—a by no means rare disease—occurring quite independently of the injury

The *treatment* of sympathetic ophthalmia is one of the most difficult problems in ophthalmology, and often demands the exercise of great judgment

It is, in the first place, prophylactic In every case of perforating wound, with or without the retention of a foreign body, the question of excision of the eye on account of danger to its fellow arises It may be assumed as an axiom that *sympathetic ophthalmia never occurs after the excision of an injured eye unless it has already commenced at the time of operation* Hence, early excision is a positive safeguard against the disease The injury to the eye may, however, be otherwise trivial, so that restoration of good sight may be possible The rule should be to excise any eye which is so injured that it is improbable that useful vision will be regained In cases where this is doubtful expectant treatment may be adopted for a time. If the eye quiets down quickly it is unlikely to set up sympathetic What, then, are the chief causes which keep up irritation ? The most important are entanglement of the iris or ciliary body or lens capsule in the wound, and the presence of a retained foreign body. Every effort must therefore be made to free the iris or ciliary body from the wound by excision of any prolapse, followed, if necessary, by division of anterior synechiæ Upon the success of these efforts the retention of the eye may depend If they fail, which is most likely to be the case if the lens is also wounded, ciliary injection is certain to continue

During this expectant period the most careful watch is kept for "k p" If the eye continues irritable, with ciliary injection, photophobia, and lacrymation, and above all if "k p" appears, the eye should be excised It is seldom wise to wait longer than a fortnight unless there are undoubted signs of amelioration The slightest sign of ciliary irritation or "k p" in the other eye indicates the necessity for immediate excision of the injured eye It must be remembered that children are more susceptible than adults Care must be taken not to confuse a simple conjunctivitis with ciliary irritation

Even more difficult to decide is the treatment in those cases in which sympathetic ophthalmia has already supervened If the case is seen early, shortly after the onset of inflammation in the sympathising eye, and if the injured or exciting eye has no useful vision, this useless eye should be excised at once There is no question that the excision of the exciting eye has a good effect upon the process in the sympathising eye if per-

formed early   At a later stage there is no evidence to show
that it exerts any influence at all

The chief difficulty arises when the exciting eye has useful
vision and the inflammation in the sympathising eye is severe
If this is the condition soon after the injury it may be wise to
excise the injured eye   If, however, a considerable time has
elapsed since the injury, excision of the exciting eye is likely
to have little or no influence upon the process   Moreover, in
the end the injured eye may have better vision than the
sympathising one, for if the iridocyclitis is severe the sympa
thising eye may be lost in spite of all efforts   Under these
conditions therefore the injured eye should be retained

The treatment of the sympathetic iridocyclitis is that of
iridocyclitis in general (vide p 273)   In addition to atropine,
hot bathings rest in a dark room, leeches &c, the patient
should be brought rapidly and thoroughly under the influence
of mercury   Mercurial inunctions should be pushed, so that
salivation occurs within a week, and the patient should then be
kept on the border line of mercurialisation for a considerable
period   Massive doses of sodium salicylate have proved
beneficial in some cases   On the theory that the disease is a
protozoal infection the intravenous injection of N A B has
been advocated   the results have been encouraging   In later
stages pilocarpine injections and the administration of iodides
may assist in the absorption of exudates, and lead to improve-
ment of vision   Perseverance in these measures, aided by
general tonic treatment is of the utmost importance

Recently an old procedure, the formation of a "fixation
abscess   has been advocated for sympathetic ophthalmia
(van Lint and Coppez)   One c c of pure oil of turpentine
is injected subcutaneously in the flank   An aseptic abscess
develops and is opened on the seventh day   Shock therapy
(vide p   694) is at least as effective especially typhoid para
typhoid vaccine or antidiphtheritic serum.

Improvement of vision may occasionally be obtained by
operation but no such interference is to be contemplated until
all inflammation has subsided and the eye has been quiet for
several months   In the milder cases an optical iridectomy
may do good   In the worst cases so long as there is percep
tion and moderately good projection of light   more desperate
operations   such as extraction of the lens &c., may be justi
fiably undertaken if the other eye is blind or has been removed

CHAPTER XXII

Operations upon the Eyeball

ANÆSTHESIA AND AKINESIA FOR EYE OPERATIONS

In most ophthalmic operations, and particularly in intra ocular operations, it is desirable to have the conscious co operation of the patient and to avoid the risks of the after effects of general anæsthesia Hence local anæsthesia, with or without pre medication, should be used except for neurotic and highly strung patients For these the previous adminis tration of a sedative may suffice , if not, a general anæsthetic must be used

Local Anæsthesia (1) *Surface Anæsthesia* Cocaine and its many derivatives are readily absorbed by the conjunctiva and cornea, and produce complete anæsthesia after instilling 4 drops of a 2 per cent solution at intervals of five minutes The iris, however, is not rendered completely anæsthetic by this method Cocaine occasionally causes alarming symptoms in old and debilitated patients and as an idiosyncrasy but this is very rare as a precaution sustained pressure over the lacrymal sac during instillation will prevent absorption from the nasal mucous membrane Neither cocaine nor pantocain must be used for hypodermic injection, novocain being much safer Pantocain is preferable to cocaine as it neither damages the corneal epithelium nor does it dilate the pupil The cornea remains clear and the sense of pressure is abolished so that the weight of instruments is not felt Pantocain (also known as dessicain) is a novocain derivative, readily soluble in water, is stable when boiled, and mixes well with adrenaline It produces a burning sensation and blepharo spasm for about a minute, and a slight hyperæmia which disappears in three to five minutes

(2) *Infiltration and Regional Anæsthesia* Infiltration anæsthesia is used in ophthalmic surgery both to eliminate pain and to paralyse muscles for protective purposes When injecting the tissues it is essential to keep the needle point moving and to withdraw the piston slightly from time to time

so as to be sure that the injection is not being made into a blood vessel Novocain or novutox should be used, and their combination with adrenaline prolongs the action and reduces absorption and toxicity Novutox is composed of novocain quinatoxine, benzoic acid, and Ringer's solution It is isotonic, self-sterlising, and does not irritate the tissues It is specially useful in cases of acute dacryocystitis, lid abscess and hordeolum

Infiltration anaesthesia with novocain and adrenaline (novocain (2 per cent), adrenaline 1 in 10 000) is employed for operations on the lids for the removal of growths, injuries and plastic repairs, and electrolysis of the lashes The lid margin is difficult to anaesthetise, a fine needle should be used and the injection given slowly and thoroughly To effect anaesthesia of the iris 1 c c of novocain (4 per cent) is injected into Tenon's capsule about half way between the temporal border of the superior rectus and the upper edge of the external rectus A fine needle is used, and care is taken to insert it very obliquely through the conjunctiva to avoid the site of a vena vorticosa, and to keep close to the sclera The injection is made just behind the equator This is safer than giving a retro ocular injection of 1 c c of novocain (4 per cent) a procedure in which a fine needle, 5 cm long is passed through the skin of the lower lid along the outer wall of the orbit for 4 cm and then turned medially for about 1 cm

In cases when a general anaesthetic is undesirable the eye can be removed painlessly by an injection of 6 c c of novocain and adrenaline into the apex of the orbit

In intraocular operations temporary paralysis of the orbicularis muscle is necessary in order to prevent squeezing together of the lids For this purpose 4 to 5 c c of novocain and adrenaline are injected down to the periosteum covering the neck of the mandible where the upper branches of the facial nerve pass forwards and upwards At the site of injection the skin can be made partially anaesthetic by applying carbolic acid (5 to 20 per cent) on a cotton applicator A 5 c c syringe with a bayonet attachment for the needle should be used, the needle should be fairly stout and 1½ inches in length The patient should be instructed to open his mouth, and the position of the condyle and temporomandibular joint is located by the operator's left forefinger After closing the jaw a point ¼ inch below the position of the condyle is selected for the insertion of the needle, which should pass straight down to the periosteum Four or 5 c c are injected,

and after withdrawing the needle firm pressure and local massage are applied   Paralysis of the orbicularis occurs within seven minutes

An alternative method is injection across the branches of the facial nerve as they traverse the malar bone   A fine needle, about 1¾ inches in length, is inserted down to the periosteum of the malar bone at a point about 1 cm below and behind the outer canthus   The needle is passed upwards towards the temporal fossa, forwards and downwards towards
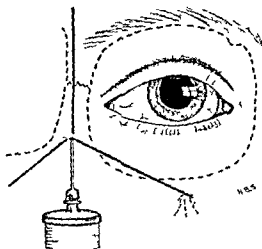
FIG 242

the infraorbital foramen, and downwards and backwards towards the tragus for an inch or so (Fig 242)

The frontalis muscle and the supraorbital nerve may also be infiltrated by inserting the needle 1 cm above the external angular process and passing it close to the periosteum along the supraorbital margin until the supraorbital notch is reached   The advantage of this method is that it provides regional anæsthesia as well as paralysis of the orbicularis muscle

Pre-medication *Basal Narcosis*   Morphia heroin, omnopon, and scopolamine are drugs which are commonly used before operation to allay fear and facilitate the quiet induction of general anæsthesia   They are liable to cause post anæsthetic vomiting and constipation, and should only be used when specially indicated as a preliminary in basal narcosis   The

action of basal narcotics is largely hypnotic Luminal gr 1,
taken by the mouth one hour before operation is effective in
rendering most adults quiet, yet still co-operative Nembutal
has been used in the same way A capsule containing 1½ grs
is given the night before operation, and one or two capsules
according to the patient's weight and age one hour before
operation Its action varies considerably, being without
effect in some persons or causing a restless semi-consciousness
in others

Intravenous Administration of Drugs The best drug for
this purpose is pentothal sodium a rapidly acting barbiturate
which produces a fall of blood pressure and intraocular pressure
good relaxation and moderately quick recovery of conscious-
ness It is a lemon yellow powder put up in ampoules of
0 5 and 1 gram dissolved in 10 c c of sterile water these
form 5 and 10 per cent solutions respectively The solution
must be allowed to clear before injection as it is important
that there should be no precipitate

A subcutaneous injection of heroin (¼ gr) and atropine
(1/100 gr) is given to adults three-quarters of an hour before
the intravenous injection It is essential to have oxygen and
carbon dioxide available and also coramine (5 c c) for intra
venous injection A good airway is necessary, and for this
purpose a Hewer s oral prop is inserted and an assistant
should be instructed to keep the lower jaw forward throughout
the anæsthesia

The 5 per cent solution gives good induction and the 10
per cent is favourable for its maintenance The injection
must be made smoothly at the rate of 2 to 3 c c in the first
fifteen seconds A pause of thirty seconds, during which the
patient is engaged in conversation allows the effect to be
observed unconsciousness generally occurs in fifteen to
thirty seconds A single injection suffices for an operation of
ten to twenty minutes duration For longer operations more
of the solution is injected at the rate of 3 to 4 c c in thirty
seconds The requisite dose varies from 0 25 gram to 1 or
1 5 gram

During the injection of the first 2 or 3 c c the pulse rate
increases returning to normal in a few minutes Respiration
is quiet but depressed, thus causing some cyanosis The
slight fall of intraocular pressure is advantageous in operations
for glaucoma and intracapsular extraction of cataract The
pupil first dilates but soon becomes normal Conjunctival
and corneal reflexes are abolished but it is wise to use panto-

cain drops, injection of novocain and adrenaline into Tenon's capsule, and facial nerve block. During anæsthesia the eyes are central and directed slightly upwards.

At the end of the operation 5 c.c. of coramine is injected intravenously. In rare cases of severe collapse this may be increased to 10 c.c., and carbon dioxide under pressure or a mixture of carbon dioxide, 5 to 7½ per cent., in oxygen given to stimulate respiration. The recovery is peaceful, and is rarely followed by headache, restlessness or vomiting. Occasionally there is a slight taste of sulphur.

The contraindications to the use of pentothal sodium are (1) children, in whom the glottis is narrow and may easily become obstructed, (2) asthma, (3) hepatic and renal disorders, (4) severe toxæmia, (5) severe anæmia and debility, (6) low blood pressure, (7) shock.

Inhalation anæsthesia is indicated in operations upon *children for squint*, application of radon seeds to the sclera, &c., for prolonged plastic operations, operations upon the orbit, and excision of the eye. In all other ophthalmic operations it is preferable to use local anæsthesia with or without basal narcosis.

The chief objections to inhalation anæsthesia for intraocular operations are the deviation of the eye, vascular congestion, and post-operative restlessness and vomiting.

In order to interfere as little as possible with the operator the anæsthetic should be administered through an endotracheal tube connected with one of the modern types of apparatus. Intubation of the trachea by the nasal route is of value in those plastic operations in which a mucous membrane graft is cut from the lip. As this method may produce granulomata in the larynx the oral route is generally preferable.

The anæsthesia must be deep enough to abolish reflexes, since sudden straining or coughing may have disastrous consequences in intraocular operations.

The deviation of the eye can be corrected by an assistant fixing it with Colley's forceps and holding it in the necessary position. A much safer method in intraocular operations is to transfix the insertion of the superior rectus muscle with a stitch which is then tied over a boss on the speculum or held by an assistant.

Vasodilatation may be reduced by the instillation of adrenaline if ether or nitrous oxide are being used. It should not be used with chloroform anæsthesia, as auricular fibrillation and heart failure have been known to result.

The severity of post-operative vomiting may be reduced by ensuring the absence of solid food in the stomach and the administration of nembutal or other suitable sedative   The administration of glucose twenty four hours before and in a saline enema after operation, together with injection of 5 units of insulin before and after, is indicated when a considerable quantity of lipiod solvent is used

Chloroform is more dangerous than ether, but it must be employed when diathermy or a cautery is used, and it is generally more suitable for children

OPERATIONS UPON THE CORNEA

Paracentesis for hypopyon ulcer has already been described (*vide* p 209)   Paracentesis for cyclitis is performed in identically the same manner as in the second method there described

OPERATIONS UPON THE IRIS

Iridectomy, which consists in the excision of a portion of the iris, is performed for the following conditions —(1) Prolapsed iris , (2) corneal or lenticular opacities (optical iridectomy) , (3) glaucoma , (4) as a preliminary or as part of cataract extraction , (5) threatening ring synechia (*vide* p 269), (6) ectatic corneal cicatrices , (7) foreign bodies in, or small cysts or tumours of the iris

Iridectomy for prolapsed iris has already been described (*vide* p 212)

Optical iridectomy is indicated in some cases of localised opacities of the cornea or lens, very rarely for occlusion of the pupil or subluxation of the lens   In all cases there must be proof or good reason to believe that the light percipient structures are capable of performing their functions   If the patient is old enough to have the vision tested this should show improvement when the pupil is dilated by a mydriatic   The opacities must be localised, and in the case of lenticular opacities there must be good reason to assume that they are stationary   The results are frequently disappointing

An optical iridectomy should be as narrow as possible, in order to avoid dazzling and to obtain an approximation to stenopæic vision (vision through a narrow slit, *vide* p 23)   It should not extend to the ciliary border   The site of election is down and in (Fig 243), but in the case of corneal opacities the clearest region of the cornea must be chosen unless this

happens to be above, in which case the coloboma would be covered by the lid and useless for vision

Instruments required · speculum, two pairs of fixation forceps, bent keratome, iris forceps or iris hook, de Wecker's scissors, iris repositor General anæsthesia is only necessary in very young or neurotic patients

The keratome is inserted at or just inside the apparent corneo-scleral margin, the blade being kept parallel to the plane of the iris It is pushed on until the incision is sufficiently long The handle is then depressed, so that the blade lies against the back of the cornea, the danger of pricking the lens with the point is thus reduced to a minimum The keratome is then slowly withdrawn The iris forceps are inserted closed, then opened very slightly and the iris seized just outside the pupillary margin or the iris may be drawn out with a blunt iris hook, which allows a narrower coloboma to be made The iris is drawn out of the wound and a portion excised with de Wecker's scissors A slit-like coloboma is made by holding the scissors so that the blades are in the direction of a radius of the iris (Fig 246), the narrowest coloboma may be made by a simple radial iridotomy, no iris being removed The iris is freed from the wound, unless already free, by the repositor Sterile atropine ointment is introduced into the conjunctival sac and the eye is bandaged

Fig 247—Diagram of wound and coloboma in optical iridectomy at the site of election

Iridectomy for Iritis (vide p 269) should be performed as in optical iridectomy, but in the upper part of the iris

Preliminary Iridectomy (vide p 315) When iridectomy is done as a preliminary to cataract extraction it should be done with a keratome in the upper part of the cornea and in the same manner as an optical iridectomy If there is raised tension (*vide* p 315) the section should be large, and the iris should be torn away as in iridectomy for glaucoma (*vide infra*)

Iridectomy for glaucoma has for its object the opening up of a sufficiency of the angle of the anterior chamber to permit of efficient filtration of aqueous It is essential, therefore, that the coloboma shall extend to the ciliary attachment of the iris, and that it shall be broad at the periphery It has already been pointed out that when the iris is torn away the fracture occurs at the thinnest part,

viz , at the ciliary attachment   This will generally happen
in iridectomy for acute glaucoma, if the attack is the first
or early in the history of the disease   In chronic glaucoma,
however—and the same applies to an acute exacerbation
occurring in the course of chronic or subacute glaucoma—
the periphery of the iris is firmly adherent to the corneo
sclera   When the iris is torn away the fracture will be at
the false angle and filtration of lymph will not be facilitated
The rules usually given as guidance to the correct performance
of iridectomy for glaucomas are that the section shall be peri
pheral and the coloboma wide   From the above remarks it
will be seen that a very peripheral section is not very important
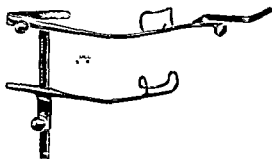
Fig 244 —Arruga Stallard speculum

in true acute glaucoma but that it has usually been thought
of importance in chronic glaucoma

In acute glaucoma and in acute exacerbations of the chronic
form a general anæsthetic or deep local anæsthesia is required,
chiefly because the high tension prevents sufficient absorption
of cocaine to render the cornea—much less the iris—anæsthetic,
partly also because the patient s self-control has been shattered
by pain and anxiety   In some of these cases and in iridectomy
for old iritis (vide p 269) iridectomy can be rendered painless
by supplementing instillation of pantocain with injection of
novocain into Tenon s capsule   It is important to wait
seven minutes before proceeding with the operation   In chronic
glaucoma if the tension is not very high local anæsthesia
may suffice   Eserine should always be instilled into the
unaffected eye (vide p 291)

In cases of acute glaucoma with very shallow anterior
chamber a preliminary posterior sclerotomy by diathermy or
a Graefe knife (vide p 477) may be done ten minutes or so

before the iridectomy, but this is seldom necessary if the treatment suggested on p 291 is carried out

Instruments required   speculum (Fig. 244), two pairs of fixation forceps, narrow Graefe cataract knife, iris forceps, de Wecker's scissors, iris repositor

The surgeon stands above the patient, using his right hand to make the section for the right eye, the left hand for the left eye   After the lids have received a final cleansing and the conjunctival sac has been douched with boric lotion or saline, sterile towels are draped round the head, neck, and chest, and the face is covered with a gauze mask in which an aperture is cut to give access to the eye   A suture is inserted 3 mm above the centre of the upper lid margin (*vide* p 488) and clamped to the towel   The speculum is then inserted and the eye fixed close to the limbus down and in, care should be taken not to rotate the globe   The knife *is held with its plane parallel to the plane of the iris*, care being taken that the back of the knife is away from the surgeon (It is an extremely awkward accident to introduce the knife with the back upwards)   The point is introduced at least 2 mm behind the apparent corneoscleral margin   It is inserted at the point corresponding with seven minutes to (right eye) or past (left eye) twelve on a clock face (Fig 245)   As soon as the point is in the anterior chamber it will look much brighter than the part in the corneo-sclera, if this is not noticeable it is probable that the knife is badly directed and is burrowing in the cornea   It is passed steadily onwards across the anterior chamber to a spot corresponding with seven minutes past or to twelve on the dial of a clock, where the counter puncture is made   In glaucoma, especially acute glaucoma, the anterior chamber is very shallow, so that it may be very difficult to pass the knife across without catching in the iris and wounding the lens, *a most disastrous accident*   The deepest part of the chamber is at the periphery, and it will usually be found easiest to coax the point of the knife round the periphery, gently pushing the iris away with the back.

Fig 245—Diagram of wound and coloboma in glaucoma iridectomy

As soon as the counter-puncture is made the knife is pushed on until 5 or 6 mm are exposed   Cutting out is performed by a series of small sawing movements, little pressure upwards being required with the very sharp knife   It is very necessary

to use these sawing movements properly, as the sharpest knife fails to cut if it is simply pressed hard against a surface

In this manner the section through the corneo-sclera is kept at a uniform distance of 1 or 2 mm behind the apparent corneo-scleral margin Some conjunctival flap has already been cut at the sides, but the middle of the knife blade is still under the conjunctiva The edge of the knife is then directed forwards and the conjunctiva cut through by one or two sawing movements

During these manœuvres care must be taken that the points of the fixation forceps are not pressing into the globe, which is
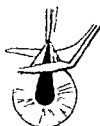
FIG 246   FIG 247

FIG 246 iridectomy with blades of de Wecker scissors held radially ,
FIG 247 with blades held at right angles to the previous position
The former method results in a narrower coloboma such as is prefer
able in optical iridectomy and in extraction of senile cataract with
iridectomy

very likely to occur owing to the attention being concentrated upon the section

If necessary the eye is now fixed with fixation forceps, just below the cornea by an assistant who also draws the eye downwards This requires a little skill If the eye is simply pulled down the wound will gape It should be rather rotated by gently pushing the points of the fixation forceps into the lower fornix The surgeon takes the iris forceps in his left hand and de Wecker's scissors in his right With a sterile swab the assistant turns down the conjunctival flap so that it lies over the cornea, unless this has been done previously with the back of the knife after completion of the section The points of the closed forceps are then inserted in the wound and carried to a point half way between the pupillary and ciliary margins of the iris at a point slightly to the right of the vertical meridian of the cornea The forceps are opened slightly, and the iris gripped The iris is pulled out and cut to the right side of the forceps This stroke makes the right

limb of the coloboma The iris is then drawn across towards
the left By this movement it is torn from its attachment for
the whole width of the section It is then drawn a little back
towards the right, so that it may not be jammed into the left
angle of the incision The free part is then cut off by a second
snip of the scissors This stroke makes the left limb of the
coloboma

The iris repositor is then taken by the surgeon, the eye still
being fixed as before The tip of the repositor is introduced
into the wound and insinuated between the cornea and the
iris on one side By a radially directed movement the iris is
smoothed out towards the centre of the pupil so that if the
edge of the coloboma is caught in the angle of the wound it
will be freed The same manœuvre is repeated on the other
side of the wound This part of the operation is very important,
and may be very difficult Only when the edge of the pupil
is in its natural position and looks circular but for the small
defect in the upper part is the surgeon convinced that the
pillars of the coloboma are free from entanglement in the
wound The conjunctival flap is then turned back over the
wound with the iris repositor, care
being taken that it is not folded upon
itself Any blood clot is carefully
removed with forceps or a swab
The surgeon lifts the speculum away
from the eye, at the same time
seizing the lid suture Removing the
speculum, he lifts the upper lid over
the wound in such a manner as to
prevent the lid from displacing the
conjunctival flap

Fig 248—Drawing up of
the iris after extraction
of cataract with incar-
ceration of the pillars of
the coloboma

Both eyes are bandaged The unoperated eye may be
uncovered after two days

The chief complications which may arise during the opera-
tion are hæmorrhage into the anterior chamber (not usually
serious, but inconvenient), wound of the lens (often not dis-
covered until opacity develops), severe intraocular hæmor-
rhage, leading sometimes to extrusion of the lens, vitreous, and
even retina

It may be mentioned that some surgeons use a keratome
in this operation Some also cut off the iris with one snip
of the scissors, the blades being directed at right angles to the
direction of the forceps (Fig 247) It is difficult to imagine
how this can produce an absolutely peripheral coloboma

The after treatment consists in complete rest in bed   The eye is dressed once daily, neither mydriatic nor miotic is instilled unless complications supervene

The chief complications arising after the operation are extrusion of the lens (due to too large a section), injury to the eye by the patient (usually during sleep) (*vide* p 495), severe intraocular hæmorrhage, &c   Delay in re formation of the anterior chamber for several days may happen, though undesirable, it will probably lead to no ill effects   The wound may bulge, with or without prolapse of iris or incarceration of the angles of the coloboma in the wound   A cystoid cicatrix may result, not altogether undesirable from the point of view of filtration in chronic glaucoma, but liable to arouse iridocyclitis or permit infection and panophthalmitis   Bulging of the wound may be due to partial subluxation of the lens which may necessitate extraction under grave technical diffi culties   Wound of the lens during the operation leads to traumatic cataract also demanding extraction

Iridotomy is section of the iris without excision of any portion   It is employed for making a new pupil when the normal pupil is closed or has been drawn up to the wound of a faulty cataract extraction with incarceration of the pillars of the coloboma (Fig 248)   In such a case it is usually done as follows   A keratome incision 3 or 4 mm long is made near the periphery of the cornea at the most suitable part, usually the temporal side   The direction of the section should correspond with the position of the proposed puncture in the iris i e , it will be approximately radial   This facilitates the opening and shutting of the iris scissors, and minimises the bruising of the lips of the wound   The closed blades, one of which is pointed of de Wecker's scissors are passed into the anterior chamber   The pointed blade is forced through the iris and passed on horizontally   The blades are then closed, a horizontal slit being made in the iris   This cuts across the stretched fibres, which retract, leaving an oval artificial pupil

Iridotomy may also be performed by sawing movements with Ziegler's sickle knife (Fig 259)

Sometimes the iris can be hooked out through a keratome incision by means of an iris hook, and a piece cut off   This gives a good pupil, but is of course strictly speaking an iridectomy

The results of iridotomy for artificial pupil are often disappointing, the inflammatory reaction causing the gap to fill with exudate which organises into scar tissue   It is,

however, remarkable how little reaction follows in some cases, especially cases of syphilitic origin

Iridotomy may be a necessary preliminary to iridectomy in cases of bombé iris   It is then usually done by passing a Graefe knife across the anterior chamber, puncturing and counter puncturing both cornea and iris   The iridectomy is done before the punctures become closed with exudate, which usually occurs soon

Division of Anterior Synechiæ is a form of iridotomy   The operation is too technical to be described in detail here

OPERATIONS UPON THE SCLEROTIC

Sclerotomy Puncture of the globe behind the equator (*Posterior Sclerotomy*) is sometimes performed by diathermy or a Graefe knife to reduce intraocular pressure temporarily in acute glaucoma

Sclerectomy   Anterior Sclerectomy is the name given to various operations for chronic glaucoma in which a fragment of

FIG 250 —
Bowmans
discission
needle with
stop

FIG 251 —
Saunders
discission
needle with
long cutting
edge

FIG 252 —
Langs knife

the sclerotic is excised   Removal by scissors as in Lagrange's operation, is now almost entirely replaced by trephining

Trephining was first used for glaucoma by Argyll Robertson (1876) and re introduced in 1909 by Freeland Fergus and R H Elliot The details of the modern method have been elaborated chiefly by Elliot The operation is indicated in chronic glaucoma and infantile glaucoma and has been re-
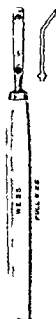
Fig 253 —
Tooke's angled
corneal splitter

Fig 254 —
Trephine

Fig 255 —
Elliot's disc forceps.

commended in some forms of secondary glaucoma e g , that following cataract extraction anterior staphyloma, &c

Instruments required Lang's speculum (Fig 118) two pairs of fixation forceps (ordinary and claw) tenotomy scissors iris repositor Lang's knife (Fig 252) or Tooke's angled corneal splitter (Fig 253) 1 5 mm trephine (Fig 254) straight iris forceps or Elliot's disc forceps (Fig 255)

de Wecker's scissors, needles, and needle-holder. The eye having been anæsthetised and a drop of adrenaline instilled, the conjunctival sac having been douched, the speculum is inserted. Tenon's capsule is injected with 1 c c of novocain at the temporal edge of the superior rectus muscle and 5 minims into the subconjunctival tissues 3 mm from the limbus at 12 o'clock. The patient is told to look towards his feet, and the conjunctiva is seized with ordinary fixation forceps 8 or 9 mm above the cornea. A large conjunctival flap is made, almost concentric with the margin of the cornea (Fig. 256): the lower ends of the wound should be well away from the
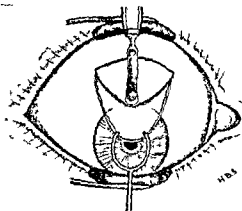
Fig 256

limbus, otherwise filtration is likely to be impeded owing to cicatricial tissue. The flap is dissected down to the upper part of the corneal margin and turned down over the cornea. It is kept stretched in this position with the iris repositor laid horizontally upon it. The subconjunctival tissue is divided with the Lang's knife or Tooke's angled splitter, the utmost care being taken to avoid button-holing the flap The edge of the cornea is thus clearly defined, and the dissection is carried into the cornea so that the superficial lamellæ are dissected up with the flap for about 1 mm The trephine is then applied, so that half the aperture lies on the cornea, the other half on the sclera The corneo sclera disc is cut by a few rotatory movements. When the anterior chamber is entered aqueous escapes, and the pupil is displaced upwards

The trephine is removed, a knuckle of iris protrudes from the wound and the disc is forced out. It usually remains attached by a small hinge. By tilting the trephine slightly forwards so that the corneal side of the disc is cut rather more deeply than the scleral, it is generally possible to insure that the hinge shall be on the scleral side. The disc is seized with Elliot's disc forceps and excised with de Wecke's scissors (Fig 257). The root of the iris is then picked up with straight iris forceps, drawn slightly downwards and from side to side so as to produce a peripheral iridectomy. The cornea is gently stroked downwards with a repositor until the pupil is round and clear of the trephine hole. During these manœuvres the
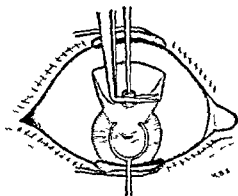
Fig 257

assistant must keep the flap well stretched downwards with the repositor (not forceps) so as to avoid it also being button-holed—a rather serious accident. The flap is then replaced, fixed at the summit by a single suture and smoothed down, the speculum is removed and the lid lifted over the wound.

There is a great tendency for iritis to develop immediately after trephining. Hence atropine should always be used on the following day and for several days afterwards.

The chief complications at the operation are making the trephine hole too peripheral, often with consequent escape of vitreous and incarceration of the ciliary processes, button-holing the flap either with the trephine or de Wecker's scissors, escape of the corneo scleral disc into the anterior chamber, and non presentation of iris in the wound. The last com

plication is usually due to slow escape of aqueous owing to the trephine being blunt

There is often considerable delay in the re formation of the anterior chamber   In rare cases it never re forms the lens becomes opaque, and vision is usually lost

Later complications are iritis detachment of the choroid (*vide* p 3.0) blockage of the wound with iris, ciliary body, lens or vitreous failure of filtration from dense cicatrisation, &c Owing to the prominence and thinness of the overlying con junctiva late infection may occur long after the operation—it occurred in only 14 cases out of 536 trephinings at Moorfields Eye Hospital (Davenport)

OPERATIONS UPON THE LENS

Discission or Needling of the intact lens should rarely be performed after fifteen years of age , it may be employed up to thirty or even thirty five but the nucleus of the lens is then likely to give trouble   It is indicated in most cases of dense lamellar cataract   some cases of congenital cataract, and some cases of high myopia   Dis
cission is used at any age for the division of dense secondary cata ract (after-cataract)

Needling of the soft lens in young patients usually requires a general anaesthetic, though it is quite pain less under cocaine   The pupil must be fully dilated with atropine
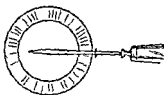
Fig 2.8 —Diagram of discis sion with one needle

Instruments required   speculum (Fig 244) fixation forceps cataract needle (Figs 250 251) I prefer a needle with a fairly long cutting edge   It is best to perform the operation in a darkened room with oblique illumination   The surgeon stands above the patient   The conjunctival sac having been douched, and the speculum in serted, the eye is fixed down and in (right eye) with fixation forceps held in the left hand   The needle is introduced just *outside* the limbus (Fig 258), i e , *through the conjunctiva* and sclero-cornea, in a plane parallel to that of the iris, at a point just above the horizontal meridian of the cornea It is carried through the anterior chamber until the point reaches the lower part of the pupil   The handle is then slightly raised, so that the point just perforates the lens capsule   The handle is then moved so that it and the

point move through arcs of circles which have their centre at
the spot where the shaft is engaged in the corneo sclera
Having thus made a curved, more or less vertical incision in
the capsule, a second incision is made at right angles to it
This is done by very slightly withdrawing the needle so as
to disengage it   It is then passed farther on towards the left
side of the pupil   The handle is again slightly raised, and
at the same time rotated, so that the cutting edge is brought
in contact with the capsule   As the needle is slowly with-
drawn a straight incision is made in it in a horizontal direc
tion   When this is sufficiently large the handle is depressed
The handle is rotated so that the plane of the blade faces
upwards, and the needle is quickly withdrawn from the eye
By withdrawing it quickly no aqueous should be lost   If
much aqueous is lost, anterior synechia may result   Sterile
atropine ointment is introduced into the conjunctival sac,
and both eyes are bandaged

    The most important point about after treatment is keeping
the pupil well dilated, which is done by atro-
pine ointment three or four times a day   There
is always some ciliary reaction   The amount
of swelling of the lens fibres depends upon the
size of the incisions in the capsule, but also
varies with different lenses   The reaction is
often very slight in cases of true congenital
cataract   in these cases the iris responds
scarcely at all to atropine   If it is particularly
desired to avoid the necessity of a subsequent
curette evacuation the incisions should be quite
small in the first operation   If it is intended
to perform a curette evacuation (*vide* p 484)
the incisions may be as large as possible, and the
needle may even be introduced moderately
deeply into the lens and the fibres broken up
In these cases, and occasionally when it is not
anticipated, there is great swelling of the lens,
the anterior chamber becomes filled with flocculent masses,
there is intense ciliary injection accompanied by raised tension
and pain   The tension sometimes subsides in a few hours with
leeching but if not must be relieved at once, or the sight will
be seriously damaged by secondary glaucoma   A curette
evacuation is then done (*vide* p 484)   In cases in which no
curette evacuation is performed a second and third needling
will usually be necessary before a clear opening is obtained

Fig 250—
Ziegler s
knife

Intervals of several weeks or even months may elapse until the absorption set up by the previous operation is complete The final needling will be of the type of a discission for secondary cataract

Since time is of little importance in the case of children compared with safety to the eye, I prefer to avoid curette evacuation in these cases if possible Simple needling causes little reaction, and septic infection is very rare if a subconjunctival puncture is made, as recommended above Excessive swelling of the lens and curette evacuation cause much more disturbance, and the risks of sepsis are greater, for the swollen lens substance is an excellent culture medium

Discission of Secondary Cataract (after cataract) (*Syn —*
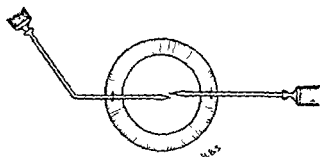
Fig 260 —Diagram of discission with two needles

Capsulotomy) is performed in exactly the same manner as discission of the soft lens if the after cataract is not too dense to be divided by a single needle Some surgeons advise needling every case of senile extraction as soon as the eye has quieted down, i e , in a fortnight or three weeks the capsule is then soft and easily divided If there has been iritis or iridocyclitis needling is contraindicated until all signs of inflammation have passed off , hence a careful search for " k p " must be made in every case

If the capsule is dense and thickened a Ziegler's knife may be used (Fig 259), or two needles may be employed, the shaft of the one used on the nasal side being bent to an angle of 135° By the latter method no undue strain is thrown upon the ciliary body, and the membrane is prevented from tearing away from the ciliary body instead of being torn in the centre The eye is fixed by an assistant The needles are introduced

16—

with the flat surfaces upwards through the cornea at opposite sides of it in the horizontal meridian 3 or 4 mm internal to the apparent margin (Fig 260) They are passed through the centre of the membrane close to each other, and the cutting edges are swept in opposite directions one up and the other down, care being taken that each needle rotates around the spot on the shaft which is engaged in the cornea In this manner the points are drawn apart, and the membrane is cut A further attempt may be made to tear it in the direction at right angles The needles are withdrawn quickly so that aqueous may not be lost Atropine is instilled, and the eye is bandaged There is seldom much reaction, unless the previous operation has been faulty, in such cases the additional irritation may precipitate an attack of sympathetic oph thalmia

When the membrane is very dense it is often best to divide it with scissors as in iridotomy (*vide* p 476), or the very ingenious canula scissors may be employed They were invented many years ago but fell into disrepute owing to the loss of eyes from sepsis They should be kept in alcohol when not in use A small peripheral puncture with a broad needle is first made, and through this the canula scissors are introduced

It may be mentioned that needling operations are by no means so simple as they appear in the hands of an experienced operator Every movement of the needle must be made round the spot where the shaft penetrates the globe

Curette Evacuation or Linear Extraction is the operation whereby after discission whether accidental (traumatic cataract) or intentional, the softened lens matter is let out of the anterior chamber

Instruments required speculum (Fig 244) fixation forceps, bent keratome curette (Fig 262) lens expressor (Fig 266) iris repositor irrigation apparatus (*vide* p 494), (toothed capsule forceps) Local anæsthesia suffices, except in the case of children or unruly patients

The pupil must be fully dilated with atropine The position of the section is of little importance , some surgeons place it above, where it is under the upper lid, others below The surgeon stands accordingly either above or at the side of the patient

The conjunctival sac having been douched and the speculum inserted the eye is fixed with fixation forceps The keratome is passed through the cornea 1 mm internal to the apparent margin (cf wound in Fig 213) with the blade parallel to the

plane of the iris It is pushed on until the incision is about
5 mm long The point may be dipped so as to pass into the
lens without disadvantage, and the incision may be increased
as the keratome is being slowly withdrawn by extending each
angle, using the two edges of the keratome like knives Toothed
capsule forceps may be introduced into the anterior chamber,
opened for 3 mm , gently pressed into the capsule and closed

FULL SIZE 2 x

FIG 261 — Graefe cataract
knife A slightly broader
knife is used in cataract
extraction than in glaucoma
iridectomy it has the ad
vantage of being less resi
lient The knives used for
glaucoma iridectomy are
generally re ground cataract
knives
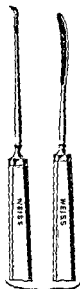
FULL SIZE

FIG 262 — Cys
totome (Moor
fields pattern)
and curette
(These should
not be at the
two ends of the
same instru
ment.)

Movements of 2 mm to the temporal and nasal sides and
upwards will remove a piece of capsule, diminishing the risks
of dense after cataract in the pupillary area The tip of the
curette is then gently insinuated just within the edges of the
wound, not quite into the anterior chamber Slight pressure
is exerted upon the peripheral lip, and the soft lens matter
travels along the groove of the curette No attempt should
be made to remove the whole of the lens matter, on account
of danger of rupture of the suspensory ligament and escape

of vitreous, the remnants will be absorbed There is no probability of the iris prolapsing or becoming incarcerated in the wound if it is properly dilated, but the repositor should be gently inserted so as to push back any lens capsule which may have prolapsed Sterilised atropine ointment is inserted and both eyes are bandaged

Usually the ciliary irritation is greatly benefited by the operation The greatest care must be exercised as to surgical cleanliness, for most of the accidents from infection in treating soft cataract occur, not from needling, but from curette evacuation Anterior synechia of iris or capsule, iridocyclitis, or sympathetic ophthalmia may occur, but are happily rare

Some surgeons extract soft cataracts by the linear method without previous discission This mode of treatment is not advocated

Extraction of Senile Cataract may be performed with or without iridectomy The iridectomy is performed by some surgeons six weeks or more before extraction I advise this method only in certain cases of immature or complicated cataract (vide p 315), and in cases where it is necessary to operate in spite of some doubt as to the sterility of the con-

FIG 264—Schncider's angular scissors
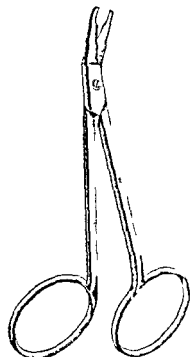
junctiva after thorough preliminary treatment Infection is likely to be more under control after iridectomy than after extraction and the behaviour of the eye in the first operation is a guide to its probable behaviour after extraction

In every case of cataract, before operating the condition of the patient's conjunctiva and lacrymal apparatus is thoroughly investigated If there is any regurgitation of tears, mucus, or pus on pressure over the lacrymal sac, the condition must be cured (vide p 651) before operation If there is any conjunctivitis it must be treated and cured, as shown by the absence

of pathogenic organisms on bacteriological examination Some of these cases are very troublesome (*vide supra*), in case of doubt, the patency of the nasal duct should be demonstrated by syringing

The usual preparation of the patient—bath, purgative, and so on—is made as for any major operation The lids are cleansed with ether soap on the previous night Luminal (gr 1)
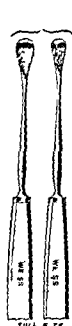
FIG 264 —
Critchett's
lens spoon

FIG 265 —
Vectis

FIG 266 —
Arruga's lens
expressor

taken one hour before operation is an adequate sedative in most cases and local anæsthesia usually suffices

There are two chief methods of performing cataract extraction extracapsular and intracapsular Intracapsular extraction should be employed only by highly skilled operators Extracapsular extraction with iridectomy ("*Combined Extraction*") is the simplest operation, and '*Simple Extraction*" (with or without a peripheral button hole iridectomy) should only be attempted after experience has been acquired by the combined method

There are many varieties of technique advocated by experienced operators The simplest technique for combined

extraction will be described first, and then a more elaborate technique for simple extraction Intracapsular extraction will be only briefly described

The preparation of the eye immediately before operation is the same in all cases The eyelashes are cut short, and git mercurochrome (1 per cent) instilled after irrigation with normal saline solution The skin of the lids is dried and painted with iodine or metaphen (1 in 2,500) Four drops of pantocain (1 per cent) are instilled at one minute intervals,
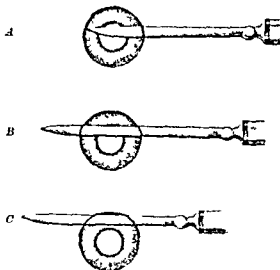
FIG 267 —A Cataract section commencing the counter puncture B Counter puncture made C' Commencing the section through the limbus

and then 2 drops of adrenaline (1 in 1,000) One drop of pantocain is also instilled into the other eye to diminish the risk of closure of the lids An injection of novocain may be made into Tenon's capsule (vide p 466) Sterile towels are draped round the head, neck and chest, and the face is covered with a gauze mask in which an aperture is cut to give access to the eye The orbicularis oculi is temporarily paralysed by an injection of ½ c c novocain (2 per cent) (vide p 466) About 3 minims of novocain are injected into the centre of the upper lid 3 mm from the lid margin, and after waiting seven minutes a No 1 white silk suture is passed through the skin at this site and then clamped to the towel, the upper lid being retracted upwards

The surgeon stands above the head of the patient, making the section with his right hand for the right eye, and with his left hand for the left eye   Some surgeons stand below and at the side for the left eye, and cut away from themselves, using the right hand

Cataract Extraction with Iridectomy ("*Combined Extraction*")   Instruments required   5 c c syringe, eccentric end with bayonet lock for 1¾ inch needle (for facial nerve block), 1 c c syringe with 1¼ inch needle (for Tenon's capsule injection), needle holder, No 1 white silk on needle for skin , straight scissors , speculum (Lang's (Fig 118) or modified Arruga's (Fig 244)), Graefe cataract knife (Fig 261), bent iris forceps , de Wecker's scissors , cystotome (Fig 262), curette (Fig 262) or lens expressor (Fig 266) , two iris repositors , [Sinclair's corneal scissors (Fig 263) , lens spoon (Fig
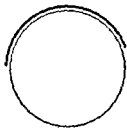
Fig 268 —Diagram of wound in extraction of senile cataract
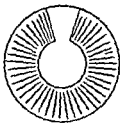
Fig 269 —Diagram of coloboma in cataract extraction with iridectomy

264) or vectis (Fig 265) , anterior chamber irrigator]   The instruments in brackets are not required for uncomplicated extraction, but must always be ready

The following description applies to operation upon the right eye

The speculum having been inserted, the patient is told to look towards his feet and a little outwards, and the eye is fixed with fixation forceps applied just outside the limbus directly downwards or preferably down and in, below the horizontal meridian of the cornea   The point of the Graefe knife is inserted in the apparent corneo sclera margin at a point 1 mm above the horizontal meridian of the cornea, care being taken that the cutting edge is upwards (Figs 267, 268)   It is passed across the anterior chamber to the corresponding spot on the opposite side   The knife is made to cut out in exactly the same manner as in iridectomy for

glaucoma (*q v*) but following the corneo scleral margin A conjunctival flap should be made as in that operation but it will be narrower at the sides since the section is farther forwards It may be made slightly broader above by carrying the conjunctival incision a little upwards after the corneo sclera has been divided before turning the knife to cut directly forwards The conjunctival flap is then turned down over the cornea by means of the back of the knife

The fixation forceps are then removed If the patient is unsteady they are handed over to an assistant who applies them below the cornea and maintains fixation If the patient is submissive he is simply told to keep looking towards his feet all the time If Tenon's capsule has not been injected he is warned that he may feel a little pain during the next stage but that he must keep still

The iris forceps are taken in the left hand and the de Wecker's scissors in the right (irrespective of the eye which is being operated upon) The closed points of the forceps are inserted at the centre of the wound and passed straight downwards to just above the pupillary margin of the iris The blades are opened slightly and the iris seized and drawn out of the wound The piece of iris grasped is cut off with one snip of the de Wecker's scissors the blades of which are held radially to the iris *i e* with the points directed upwards (Fig 246)

The iris repositor is now taken and the iris replaced as in the operation for iridectomy (*q t*) Particular care is taken to free it from the angles of the wound usually an easy task at this stage owing to the support afforded by the lens and the smoothness of the surface of the capsule

The patient still looking towards his feet, the cystotome is introduced with the cutting edge directed towards the left and slightly upwards It is passed on until the point is near the lowest part of the pupillary margin The cutting edge is then directed backwards the handle is slightly raised and the lens capsule is incised vertically as the instrument is slowly withdrawn

The cystotome is then taken in the left hand and the curette in the right The back of the curette or the lens expressor is placed horizontally upon the lower part of the cornea Gentle but firm pressure is made upon the cornea in a direction backwards and slightly upwards This causes the nucleus of the lens to be tilted so that the upper edge appears presenting in the wound The lens nucleus is coaxed out of the wound by repeating the pressure with the curette, but more

in refined sterile liquid paraffin and this is covered by a pad
of cotton wool moistened with normal saline solution   A pad
is put over the other eye, and both are bandaged with a
many tailed or a Moorfields' (Fig 270) bandage   A Cartella
shield (Fig 271) is placed over the operated eye and secured
by strapping

Remarks upon the Operation   The size of the section depends
upon the probable size of the nucleus of the lens   It must be
remembered that the cortex is soft and broken up, the width
of the incision must be slightly larger than the diameter of the
nucleus   In black cataract the whole lens is sclerosed, so that
a very large section must be made, in these cases it should
involve half the circumference of the cornea   More harm is
done by bruising the edge of the wound than by having a
wound which is unnecessarily large   If the nucleus does not
come forward through the wound with moderate pressure of
the curette it is probably because the section is too small   The
wound should then be enlarged with the probe pointed bent
scissors (Fig 263)   The probe point on one blade is inserted
between the iris and cornea at one angle of the wound,
which is then extended by a single snip   The same manoeuvre
may be repeated at the other angle

In making the section the aqueous may escape prematurely,
so that the iris floats up in front of the knife   If this happens
the knife should be raised as if to lift the eye forward, the
aqueous, dammed up in the posterior chamber, can then flow
forwards through the pupil and the iris falls back   If this
manoeuvre fails the section must be completed in the usual
manner, though the iris is wounded, either a hole or a complete
coloboma being cut out of it   Cutting the iris causes pain
unless Tenon's capsule has been injected and is likely to make
the patient flinch   screw up the eye, or completely lose control
    Moreover the coloboma is generally irregular   The
accident is usually due to hesitation in pushing the Graefe
knife steadily forward or to pressure—often unnecessarily—
exerted on the eye by the fixation forceps   It is least likely
to occur if the passage of the knife through the anterior
chamber and the commencement of the section are all part
of a single steady forward sweep of the blade, the handle of
the knife being depressed directly the counter puncture is
made   In this manner the broad part of the blade is brought
over the iris as quickly as possible   There should, however,
be no haste, every movement being made with deliberation
but not too slowly.

Old people sometimes have very rigid sclerotics   In these cases the cornea collapses and becomes saucer shaped   This is of no consequence and requires no special treatment.

Sometimes a bubble of air enters the anterior chamber   This also is of no consequence, as it soon becomes absorbed

The iris is more easily cut off by holding the de Wecker's scissors at right angles to the direction of the forceps, *i e*, horizontally (Fig 243)   This makes a larger coloboma, which is unnecessary and has some disadvantages

Hæmorrhage may occur into the anterior chamber   The blood is derived from the conjunctival flap or from an hyper æmic iris   An attempt may be made to wash it out by irrigation before it clots, or to remove the clot with forceps

The capsule is divided in all sorts of different directions by different operators   Some surgeons remove a part of the anterior capsule by capsule forceps (*vide* p 485), which has very decided advantages, but has also its own special dangers

The most serious accident which may occur during extraction is prolapse of vitreous at an early stage   It may be due to inherent weakness of the suspensory ligament, which gives way while the section is being made or the iridectomy done   This cause is most likely to be present in complicated cataracts   In such cases it is a good plan to discard a speculum, an assistant holding the lids apart and raised off the eye by means of a pair of Desmarres' or similar lid retractors   More commonly loss of vitreous is due to undue pressure on the eye by the fixation forceps   In concentrating all their attention on the section beginners often allow the left hand to dig the fixation forceps into the globe   Special attention must there fore be devoted to the avoidance of this mistake, which has also the lesser disadvantage of forcing out the aqueous and allowing the iris to float up in front of the knife   Escape of vitreous may also be due to pressure with the curette in the attempt to expel the lens   The necessity of such great pressure is probably owing to the wound being too small or to the capsulotomy having been inefficiently performed   The former contingency has already been dealt with   The latter is over come by more careful repetition of the capsulotomy   If pressure with the curette causes the vitreous to appear without any sign of the engagement of the edge of the lens in the wound resort must be made at once to scoop extraction   Hence the importance of having the spoon or vectis always in readiness in every case of extraction   The spoon is passed directly backwards into the vitreous so as to make certain

that it passes behind the lens. It is then rotated forwards so that the lens is caught between the spoon and the back of the cornea. The lens is kept pressed up against the cornea and is removed by a rapid further rotation of the spoon. Some vitreous is certain to be lost but it is imperative that the lens should be delivered or the eye will almost inevitably be lost. The eye is dressed at once in these cases without any endeavour being made to replace the iris as any such manoeuvre is likely to lead to further loss of vitreous. In spontaneous rupture of the suspensory ligament and in other cases badly managed the lens may sink back into the vitreous. In such cases it is usually futile to attempt to remove it. The eye should be dressed at once and if the lens floats up into the pupillary area at a later date a further attempt may be made to remove it.

Prolapse of the vitreous after delivery of the lens is less serious though it increases the tendency to cyclitis with opacities in the media and may be followed by detachment of the retina. If much vitreous is lost the iris is always gradually drawn upwards so that in course of weeks or months the pupil is much displaced and the lower part of the iris is stretched (Fig 218). This condition may also occur from incarceration of the pillars of the coloboma in the wound. It may be necessary to do an iridotomy or some such operation to make an artificial pupil so that vision may be restored.

When the cataract is immature some of the soft lens cortex remains in the eye so that the pupil is not black but contains greyish masses. Much of the retained lens substance can be removed by stroking the cornea upwards with the curette or lens expressor repeating the movements used for delivering the lens but with less pressure. It is usually impossible to remove it entirely in this manner. If it is left in the eye it gradually becomes absorbed but it has the disadvantages of tending to irritate the eye and cause slight iridocyclitis and of leading to the formation of a denser after-cataract. Some surgeons irrigate the anterior chamber with normal saline solution. This method gets rid of the lens substance but in my experience is very liable to set up a mild iridocyclitis, in spite of the strictest antiseptic precautions. Irrigation may be performed with an undine to the nozzle of which an india rubber tube is attached having a flattened canula at the other end. The tip of the canula should be introduced just inside the lips of the wound and the undine should not be held too high, only a gentle stream of fluid being used.

After treatment There is usually some aching and smarting in the eye as soon as the effects of the pantocain wear off It lasts for four or five hours hence it is best to operate in the morning so that the patient may have a good night's rest If the pain interferes with sleep a dose of aspirin will usually relieve it, or a mild bromide draught may be given

The patient lies quietly upon his back, with the head and shoulders raised He is directed to avoid all straining A sneeze may be inhibited by pressure with the finger on the upper lip close to the septum of the nose *All* patients should have their hands loosely tied to the bed at night so that they are unable to touch the eyes Many eyes are lost from neglect of this precaution for patients often knock or rub their eyes when they are half asleep

The food must be fluid during the first few days, no aperient is given for three or four days

On the day following the operation the bandage is removed, the lids are bathed with warm boric lotion, gently separated, and a drop of sterile 1 per cent atropine solution instilled The wound may be inspected, but should not be disturbed more than is absolutely necessary

On the second day it is examined more thoroughly The cornea should be bright, and the pupil round and well dilated Faint greyness in the cornea above (striate opacity, *vide* p 243) need cause no alarm Another drop of atropine is instilled If the pupil is not well dilated on the third day there is probably some trace of iritis, and the atropine should be instilled more frequently, and it may be advisable to resort to hot bathings In most cases there is no iritis, and after a transient ciliary injection the eye quiets down so that it is almost free from injection in a week or ten days

On the fourth or fifth day the unoperated eye may be left unbandaged If both eyes are kept bandaged too long old people often become delirious On the slightest sign of wandering in speech the unoperated eye should be uncovered at once If this eye is blind or has very defective vision the dressing should be taken off the operated eye, and dark protective goggles worn during the daytime

It is wise to keep healthy patients in bed for a week Most cataract patients, however, are old, and extremely liable to hypostatic congestion of the lungs Such patients should be propped up in bed on the third or fourth day, and allowed to sit up out of bed soon after A light dressing is kept on for ten days or a fortnight, afterwards smoked glasses are worn

until cataract glasses can be ordered, i e, in about six weeks
It is very important that smoked glasses should be worn
continually, otherwise the patient is quite likely to develop
erythropsia (q v)

Cataract Extraction without Iridectomy ("Simple Extraction") For this method a somewhat more elaborate technique
will be described   In addition to the instruments required for the previous
operation a No 1 black silk
suture on a needle is needed
for the superior rectus and

Fig 272—Eyeless needle

a corneo scleral eyeless needle (Fig 272) armed with 000
black silk   A modified Arruga's speculum the weight of
which is taken by the bridge of the nose and the malar region
should be used   Also conjunctival block (Fig 119) and
smooth conjunctival forceps capsule forceps, lens expressor
and blunt iris hook

After preliminary preparation and the insertion of the
speculum the tendon of the superior rectus is seized by
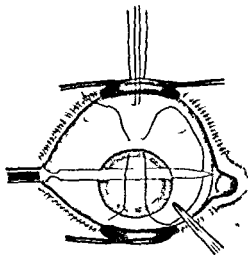
Fig 273

conjunctival forceps and an injection of 0 5 c c of novocain
(4 per cent) is made into the belly of the muscle and behind

to the level of the equator of the eye The needle is then turned to the temporal side, keeping close to the sclera, and 0 5 c c is injected into Tenon's capsule This produces paresis of the superior rectus, so that the patient cannot look up, and also anæsthetises the ciliary nerves passing to the iris and ciliary body

The tendon of the internal rectus is seized by fixation forceps and a corneo scleral suture passed through the superficial layers of the cornea transversely for 2 5 mm at a point about 1 5 mm on the corneal side of the limbus , it is then passed through conjunctiva and episclera 2 5 mm
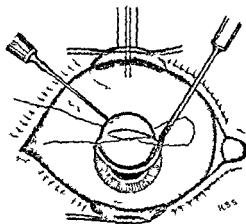
Fig 274

above and exactly opposite and parallel to the direction of the corneal suture (Fig 273) The corneo scleral section is made between the cornea and scleral insertions

Fixation forceps are applied firmly to the conjunctival and episcleral tissues 1 mm behind the limbus in the lower nasal quadrant The forceps should then be held up so as to keep the eye drawn slightly forwards and avoid pressure on it The corneo scleral section is made as already described (vide p 4·9), and is completed subconjunctivally, a narrow conjunctival flap being made, taking care not to cut the corneal part of the suture If blood enters the anterior chamber it may be soaked up by a small gauze swab applied to the wound , or if this fails it may be removed by irrigation with normal saline The corneal part of the suture is then

held, preferably in smooth forceps, and the lips of the wound gently opened to admit the closed capsule forceps, which are passed towards 6 o'clock to a point just below the centre of the anterior pole of the lens. The blades are then opened about 3 mm , the teeth pressed gently into the lens capsule, and the blades closed A downward movement for about 2 mm is followed by similar movements laterally, and the forceps are then removed, carrying with them a piece of capsule about 5 mm in diameter.

The lens expressor is then applied to the lowest part of the cornea, and the nucleus expressed in the manner already described (*vide* p 490) If the iris impedes the delivery of the nucleus it may be retracted upwards by a blunt iris hook.

When the lens has been extracted an iris repositor is inserted and the iris stroked back into position. The pupil should be quite round if not, or if the iris tends to prolapse, the periphery is gently drawn out of the wound by iris forceps and the smallest possible fold is snipped off with de Wecker's scissors The iris is then again replaced with the repositor.

If such soft lens matter remains in the eye, as in immature cataract it may be removed by massage or irrigation (*vide* p 194), and the iris again replaced.

The corneo scleral suture is tied firmly enough to coapt the edges of the wound, but not tightly. The conjunctival flap is stroked into position, and the eye bandaged.

Comparing the two operations, it may be succinctly stated that the chief advantages of *simple extraction* are : Simplicity of the operation, including especially minimum of mutilation, of instruments required, and of instruments introduced into the interior of the eye ; optical advantages of a round pupil —minimal dazzling, best visual acuity, and best field ; cosmetic advantage of a round pupil ; ease of reposition of the iris ; minimal danger of incarceration of capsule in the wound , infrequency of prolapse of vitreous ; greater protection of deeper parts of the eye from infection ; absence of pain and bleeding from cutting the iris Of these it may be remarked that the optical advantages are not overwhelmingly manifest. The cosmetic advantage is rarely of sufficient importance to outweigh the risks, though occasionally it is a justifiable argument, as in the case of an unsightly unilateral cataract in a young woman, or in a man in whom it forms a bar to obtaining employment. It is doubtful whether prolapse of vitreous is more frequent in combined than in simple extraction. Bleeding from the iris is only very exceptionally of any importance,

when there is much bleeding in cataract extraction the blood is derived from the conjunctival flap or from a too peripheral section. The chief disadvantages of simple extraction are risks of prolapse of the iris, less efficient treatment of the anterior capsule, greater difficulty in removal of soft lens matter, greater danger of ring synechia and secondary glaucoma if iritis should occur

The chief advantages of *combined extraction* are greater ease in expression of the nucleus, greater ease in removal of soft lens matter, increased facility in dealing with the anterior capsule, and therefore diminished necessity for subsequent discission, diminished risk of prolapse of the iris, diminished risk of secondary glaucoma. The chief disadvantages are greater complexity of the operation, including especially need of more instruments and of the introduction of more instruments into the eye, and greater duration of the operation, optical and cosmetic disadvantages, greater danger of incarceration of iris and capsule in the wound, greater danger of post-operative glaucoma, pain and bleeding from the iris

If there is any difficulty in replacing the iris after a simple extraction or if the pupil when the iris is reposed is not quite circular, an iridectomy should be done at once. Prolapse is liable to occur within the first twenty four hours after the operation. If it is not treated by an immediate iridectomy a very serious condition will result. The incarcerated iris will fail to withstand the intraocular pressure and a "cystoid cicatrix" will be formed. Visual acuity will be diminished by excessive astigmatism and the eye exposed to grave danger from iridocyclitis, and even panophthalmitis or sympathetic ophthalmia

Many of the disadvantages of both operations including the danger of prolapse of iris, are obviated by a modification in which after simple extraction has been performed a small button hole is made in the periphery of the iris (*peripheral iridectomy*) (*vide supra*). The aperture in the iris is peripheral, so that it is almost entirely hidden by the sclerotic, and in any case is completely covered by the upper lid while at the same time sufficient drainage from the posterior into the anterior chamber is provided for. Prolapse of iris is less likely to occur than in simple extraction, and it is quite unlikely that the capsule will be left entangled in the wound, a decided drawback to extraction with the ordinary form of iridectomy

Intracapsular Extraction. In this operation a larger section

is necessary than for extracapsular extraction : it should pass across the full horizontal diameter of the cornea   Aft   the section is made a small button hole peripheral iridectomy is performed   Arruga's smooth capsule forceps are introduced closed to the temporal side of the iridectomy   On reaching the pupil margin the blades of the forceps are moved over the anterior capsule in the sagittal plane and are stopped over the thickest part of the capsule just in front of the equator near the lower edge of the lens   The blades are then opened 3 mm , pressed gently backwards to engage the capsule, and closed   Gentle rotating, zigzag movements are made so as to rupture the suspensory ligament   These movements increase in excursion, and not until the lower edge of the lens is felt to be free and to move forwards is any attempt made to lift the lens and tumble it forwards   The remainder of the manœuvre consists in holding the capsule without pulling on it, and using the lens expressor in the usual way, keeping it just below the lowest part of the lens during delivery   When the lens is in the wound it is important to complete the final stage slowly and deliberately, allowing the vitreous to gravitate and the iris to slide back in place   When the lens has been removed the corneo-scleral suture is tied, sterile drops of eserine (1 per cent) are instilled, the iris replaced, and the conjunctival flap adjusted

The chief complications arising after cataract extraction are striate " keratitis " (Fig 150), incarceration of the iris in the angles of the wound, prolapse of the iris, iritis, iridocyclitis, sympathetic ophthalmia secondary glaucoma, intraocular hæmorrhage, infection of the wound, panophthalmitis, &c

Prolapse of Iris is most apt to occur after simple extraction, but may affect either pillar of the coloboma in comb ned extrac tion   It usually occurs in the first day or two but may result later from injury to the eye by rubbing or knocking it, straining, coughing, &c   It must be treated *at once* by excision of the prolapse   As the iris is irritable the operation is painful, and general anæsthesia or retrobulbar local anæsthesia is generally necessary or advisable   The wound is re-opened by insinuating the tip of an iris repositor under the conjunctival flap and gently uncovering the prolapse   The flap is turned down over the cornea, the iris pulled out with iris forceps and snipped off with de Wecker's scissors   The iris is then replaced with a clean repositor and the conjunctival flap brought back into position   A small subconjunctival knuckle of iris can sometimes be replaced by an iris repositor, but it is generally wiser to snip it off

Delayed Re-formation of the Anterior Chamber may be due to a jagged section, over riding of the lower lip of the wound, or to no apparent cause It is much less common in cataract extraction than after glaucoma iridectomy or trephining In these cases the bandage should be very lightly applied or discarded, dark protec tive goggles being worn in the daytime, and a light bandage with wire or cartella shield at night

Delayed Healing of the Wound is more likely to occur with a purely corneal section, such as some surgeons prefer The patient should be kept in bed until it is firmly healed, unless this is specifically contraindicated (*vide* p 495) Delay in healing is, however, generally due to incarceration of iris or capsule in the wound If this amounts to an actual prolapse it must be operated upon (*vide supra*), but it may be very insidious In either case the result may be the formation of a *cystoid cicatrix*, part or the whole of the scar slowly and gradually becoming more and more ectatic The eye should be carefully examined to see if the pupil or either pillar of the coloboma is drawn up or if capsule can be seen in the wound A fully developed cystoid scar should be left alone, though it causes much astigmatism and is liable to give rise to secondary infection, or iridocyclitis and even sympathetic ophthalmia

Expulsive Hæmorrhage is fortunately rare It occurs during or soon after operation in old people with arteriosclerosis or some diathesis, such as diabetes There is sudden severe pain, and on removal of the dressings the wound is found to be gaping and filled with blood clot vitreous, &c The eye is always lost and should be excised This may be necessary in order to stop the bleeding, the socket being then packed and firmly bandaged

Septic Infection may occur in spite of all precautions especially in diabetic patients It is most commonly due to the pneumo coccus, but may be caused by the streptococcus, staphylococcus aureus or even albus and many other organisms It usually occurs from the twelfth to thirty sixth hour after operation There is severe aching pain due to the accompanying acute iritis On removing the dressings the upper lid is œdematous When the lids are separated tears gush out and there is muco pus in the conjunctival sac The lids should be separated gently, if neces sary with retractors The cornea is then seen to be dull and hazy, especially in the upper part, the lip of the wound being yellow Almost invariably the infection spreads rapidly Intense iritis is set up, the pupil and coloboma become filled with exudate and an hypopyon appears Finally, the vitreous becomes infected and panophthalmitis leads to the destruction of the eye

Treatment is seldom of any avail but must be applied quickly and energetically The anterior chamber should be irrigated

with hydrogen peroxide solution The lips of the wound should
be cauterised with the galvano-cautery Subconjunctival injec-
tions of perchloride (1 in 2,000) or oxycyanide (1 in 5,000) of
mercury may be given, but add much to the pain and are seldom
of use Sulphonamide treatment (vide p 693) should be tried
A staphylococcic or polyvalent vaccine should be given and an
autogenous vaccine prepared and administered as soon as
possible

Iritis in mild degree probably occurs in all cases of cataract
extraction In more pronounced form it is specially associated
with retained lens matter (vide p 494) and diathetic states, such
as diabetes, rheumatism, gout, &c The worst cases occur with
acute septic infection Intermediate in severity are cases of
plastic iritis due to infection by less virulent organisms or in
patients with greater resistance to bacterial invasion More
insidious than any are cases of continued irritability of the eye
with mild iritis In these, spots of " k p " are found upon the
back of the cornea, so that there is also cyclitis Both in these
cases and in the cases of plastic iritis there is grave danger that
the condition is really sympathetic ophthalmia Hence it is very
essential in all cases of cataract extraction to inspect the cornea
most carefully with oblique illumination and the loupe and to do
so frequently, especially if there is an unusual degree of flushing
and lacrimation on exposure to light The other eye must also
be carefully watched If there is " k p " no needling operation
must be undertaken until the eye has quieted down and remained
quiet for many weeks It is sometimes difficult to distinguish
minute spots of lens substance on the back of the cornea from
true ' k p ', they soon become absorbed

Detachment of the Choroid Vide p 350

Secondary Glaucoma may set in after cataract extraction It
is probably usually due to peripheral anterior synechia and
incarceration of capsule in the wound (vide p 281) Sometimes
it is due to the anterior chamber being lined with epithelium.
In these cases there has been delay in healing and the conjunctival
epithelium has grown down into the anterior chamber and spread
over the surface of the iris, lens capsule and cornea These
cases are practically hopeless and cannot be diagnosed clinically
with certainty Sometimes secondary glaucoma follows needling
of the after-cataract It is usually then attributed to vitreous
extending into the anterior chamber and interfering with filtra-
tion It is doubtful if this is the true explanation These cases
usually do badly As regards treatment, where there are definite
adhesions of capsule an attempt may be made to divide

them These cases afford the best prognosis In the more
obscure cases the eye should be trephined

EXCISION OF THE EYEBALL

A general anæsthetic or deep local anæsthesia is required
The operation can be performed
almost painlessly under novocain
(vide p 165), and this method is
sometimes advisable in old people
with diseased arteries, or in
patients with heart disease

Instruments required specu
lum (preferably Lang's) two pairs
of fixation forceps, tenotomy scis
sors (Fig 275), strabismus hook
(Fig 276), blunt pointed scissors
—straight or curved on the flat
(Fig 277)

The surgeon stands above the
patient

The conjunctival sac having
been douched and the speculum
inserted, the surgeon seizes the
conjunctiva just outside the lim
bus at the highest part of the
cornea The conjunctiva is in
cised here with the tenotomy
scissors The point of one blade
of the scissors is passed under the
conjunctiva and pushed on as far
as possible round the cornea By
carrying the point out under the
looser bulbar conjunctiva it may
be taken a third of the distance
round the circumference, the
edge is then brought close up to
the limbus before the conjunctiva
is divided Still fixing the eye in
the same position the manœuvre
is repeated on the other side of the cornea Finally, the
portion below the cornea is divided The conjunctiva should
be divided completely round the cornea and close to it, in
three or four cuts
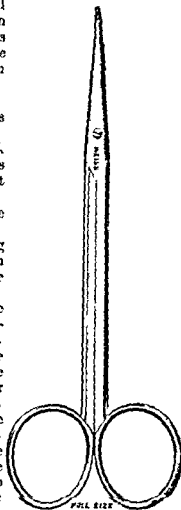
FIG 275—Tenotomy scissors.

The peripheral edge of the cut conjunctiva is then taken up by the forceps, and the bulbar conjunctiva is separated from the globe as far back as the equator in all directions by a series of small snips, the blades of the scissors being kept flat in close contact with the eyeball In this manner the capsule of Tenon is simultaneously opened

The tenotomy hook is then taken in the left hand, the scissors being retained in the right The recti muscles are taken up one by one and divided close to the globe It is well to begin with the superior rectus, since it is the most difficult to get at, especially if the other recti have been previously divided The obliques are found by passing the hook farther back and carrying it round close to the globe

The speculum is then taken and held widely open and pressed back into the orbit If the muscles have been properly divided the globe springs forwards between

Fig 2 6 —Strabismus hook flat Moorfields pattern

the blades of the speculum. The other pair of scissors is now taken in the right hand. The globe is seized with the fingers of the left hand. The points of the closed scissors are passed into the orbit—to the outer side of the eye on the right side, to the inner on the left The optic nerve is felt for with the closed scissors it is easily recognised The scissors are withdrawn a short distance, opened, and the blades pushed down, one on each side of the nerve, which is then divided The sensation of dividing the nerve is unmistakable The eyeball can then be freely drawn forwards There are probably some remnants of the obliques still attached to the globe These are divided close to the eye If the bleeding is profuse the inside of the muscle cone is packed with ribbon gauze wrung out in hot saline pressure is kept up for two or three minutes The edges of the conjunctiva are then pulled together with the fixation forceps or better drawn together by a continuous silk suture, the lids closed, and the dressing applied The latter should consist of a small spherical pad of gauze, then a round flat pad of sterilised or cyanide gauze, then a thick round pad of sterilised wool The bandage is applied with a firm pressure The patient is kept in bed for

one or two days The suture is removed after forty eight hours

If the globe is perforated and collapsed excision is more difficult The rupture should be closed by sutures before proceeding to excise the eye In children also excision is difficult The orbit is small in proportion to the size of the globe Here the manœuvre with the speculum to dislocate the ball forwards is often unsuccessful, and strong pressure may burst the eye It is best levered out with the points of the excision scissors

It is very easy to cut the sclera instead of the nerve, especially with curved excision scissors I always prefer straight scissors, indeed, straight instruments should always be used in preference to curved whenever it is possible, because it is much easier to judge the position of the point Straight scissors are particularly indicated when the nerve has to be cut long, as in excision for glioma retinæ and sarcoma of the choroid Special precautions must be taken in excision for panophthalmitis (vide p 459)

Evisceration of the eyeball is recommended only in some cases of panophthalmitis (q v) Some surgeons use it in anterior staphyloma and other conditions Although the stump affords a good foundation for an artificial eye, the operation is not to be recommended in these cases, it has been followed by sympathetic ophthalmia

Excision, with the introduction of a glass globe in Tenon's capsule is a good method in carefully selected cases and affords admirable support to an artificial eye The eye is much more
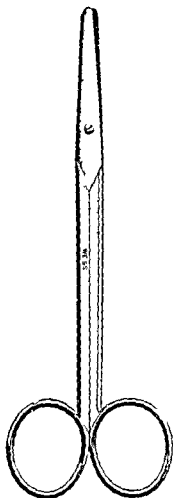
Fig 277 —Excision scissors

movable than after simple excision, so that the simulation of
a real eye is more exact   Care must be taken during the
excision to keep close to the eyeball and to injure Tenon's
capsule as little as possible   The recti muscles are drawn
together over the small glass globe by a buried purse string
suture of catgut (000 000, ten day)   The conjunctiva is
sutured by a superficial purse string suture   There is some
inflammatory reaction, with chemosis, but little or no pain
If the operation has not been well performed, the globe may
slip into the orbit, becoming loose, usually beneath the lower
lid   If this occurs it must be removed and the case treated as
an ordinary excision

An *artificial eye* should not be worn less than six weeks
after excision   A small eye is first worn for an hour or two a
day until the conjunctiva becomes used to the foreign body.
Eight or nine weeks after the operation a full-sized eye may be
worn   It is taken out at night, carefully washed, and kept in
water   If it becomes in the slightest degree rough at the
edges it must be discarded at once   This usually occurs from
chemical action of the secretion upon the enamel in about a
year, so that in any case a new eye should be obtained every
year   Various types of artificial eye are made   Snellen's
' reform " eye gives a better cosmetic effect after the ordinary
excision than the old shell, which may be used when there is
good support, as after insertion of a globe in Tenon's capsule
The methods of insertion and removal of the artificial eye
should be learnt by every surgeon by seeing it done

Contracted Socket is the result of injury, faulty excision,
cellulitis in the orbital tissues, or the continued wearing of a
rough artificial eye   The first three causes lead to the forma-
tion of dense cicatricial bands across the socket, rendering the
wearing of a prosthesis impossible.   The last cause usually
results in obliteration of the lower fornix, so that the eye
cannot be kept in place

Contracted sockets are very difficult to remedy   It is easy to
divide the bands and make a new groove to hold the eye in
position, but unless the wounds become covered with epithe
lium the edges heal together and no improvement is produced
A thorough dissection of all fibrous bands should be made,
and the raw surface covered by a Stent mould   The Stent is
cooled in situ by drops of cold saline and removed   A clamp
is applied to the lower lip, which is then everted to expose its
inner aspect   The Stent mould is placed over this, and a graft
of mucous tissue nearly twice the size is cut   The submucous

tissue is dissected off and the graft sutured in position   The Stent is secured in place over this by mattress sutures, the eyelids are closed and covered with a dressing of tulle gras gauze wrung out in saline an l a gad and bandage

The greatest difficulty is to restore the lower fornix   Max well s operation is the best for this purpose if the lower lid is uninjured   It is simple but difficult to describe   An elliptical area of skin is marked out on the lower lid   The upper incision is carried through into the socket in the position of the new fornix   The flap is about 8 mm broad in the centre   It is dissected up at the edges all round but a central elliptical pedicle is carefully retuned   The flap is tucked through into the orbit   the upper edge is sutured to the posterior lip of the conjunctival wound   and the lower edge to the anterior lip   The gap in the skin is then closed with sutures and a glass shell is inserted in the socket   The pedicle ensures the vitality of the flap and also keeps the new fornix depressed to the level of the orbital margin   If much ectropion results the scar can be re opened at a later date and a Wolfe graft of sufficient size inserted and sutured in position with eyeless needles and fine silk or gossamer horse hair   A moulded Stent is placed over the graft and retained by mattress sutures and a strip of gauze secured to the adjacent skin by mastisol

When there is a good upper fornix a simpler procedure may be tried   The conjunctiva is extensively undermined through a temporal vertical incision sufficient to admit a pair of blunt ended scissors   When the conjunctiva covering the floor of the socket is free two or three mattress sutures are passed through it in the part designed to form the lower fornix (Fig 34*) and carried down through the periosteum of the infraorbital margin with the orbicularis and skin   They are then tied over pieces of rubber tubing

In bad cases of contracted socket it is necessary to dissect away all the remaining conjunctiva and fibrous tissue   As large a Stent mould as the socket will retain is then fashioned and its centre is perforated by a hole 2 mm in diameter for the escape of discharge   An ample Thiersch graft is cut by Humby s knife an l wrapped round the Stent with its raw surface outwards   This is inserted into the socket and the lids are united by a central tarsorrhaphy

SECTION IV

ERRORS OF REFRACTION AND ANOMALIES OF ACCOMMODATION

CHAPTER XXIII

Retinoscopy

(BEFORE reading this section the student should revise his knowledge of the optical conditions of the eye and the methods of testing visual acuity by again reading Chapters III, IV., VII, and IX)

It has been already pointed out that the condition of the refraction of an eye can be estimated in various ways The systematic examination of the visual acuity will in most cases *indicate* the absence or the nature of any error of refraction   The examination with the mirror at a distance of 1 metre also indicates the refractive condition by the visibility of retinal vessels and the direction of parallactic displacement, as will be shown below, this method may be made to give very accurate estimation of the exact refraction   The indirect method also indicates the refractive condition by the apparent change in size of the disc when the large lens is moved away from the eye   By the direct method the condition of the refraction can be accurately measured if the surgeon has acquired the ability completely to relax his accommodation

Retinoscopy or, more correctly, *skiascopy* or *the shadow test*, is the most accurate means at our disposal of estimating the condition of the refraction objectively   It depends upon the fact first pointed out by Bowman, that when light is reflected from a mirror into the eye the direction in which the light travels across the pupil varies with the condition of refraction of the eye   If the light is thrown into a myopic eye from a concave mirror at a distance of 1 metre the light or, what is easier to observe, the *shadow*, moves across the pupil when the mirror is slowly tilted in the same direction

as that in which the mirror is moved (Fig 278) If a plane
mirror is used, the other conditions remaining the same, the
shadow will be seen to move in the opposite direction to the
movement of the mirror If the eye is hypermetropic the
direction in which the shadow moves is the opposite of that
with the myopic eye If the eye is emmetropic or has only
a very low degree of myopia no shadow will be visible,
the pupil will be either completely illuminated or completely
dark

The light seen in the pupil is the blurred image of the
illuminated area of the fundus as seen by the observer when
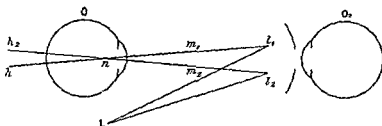
FIG 278 —Diagram of retinoscopy with a concave mirror   O$_1$ the
observed eye   O$_2$ the observer's eye   The image of the source of
light is formed at l$_1$ (the immediate source of light) by the mirror
If O$_1$ is hypermetropic a virtual image of l$_1$ is formed on the line l$_1$ n,
passing through the nodal point n as at h$_1$ If O$_1$ is myopic a real
inverted image is formed as at m$_1$ If the mirror is tilted downwards
as shown by the dotted line l$_1$ moves to l$_2$ h$_1$ to h$_2$ and m$_1$ to m$_2$
This shows that the shadow moves in opposite directions in hyper
metropia and myopia

he accommodates for the observed pupil   The shadow is
merely the image of the edge of the illuminated area

Imagine a point of light in front of an eye the pupil being
dilated and the accommodation paralysed by atropine (Fig
279)   The divergent rays which enter the eye are made con
vergent by the refractive media so that a circular area of the
fundus, varying in size according to the refraction of the eye,
is illuminated   If the point of light moves upwards, the light
on the retina will move downwards

Now consider the rays of light which are reflected from the
illuminated area   In the hypermetropic eye they will be
divergent, as if they came from a point behind the eye   This
far point, corresponding with the illuminated area, will move
in the same direction, *i e*, downwards   Now imagine an
observer, placed in front of the eye, to look towards a point of

light situated at the position of the far point, but to accommodate for the position of the observed pupil   He will see a circle of light with a blurred margin, not a point, because he is not accommodating accurately for the far point   When the illumination on the retina moves down, the circle of light which the observer sees will appear to move down also (Fig 279)
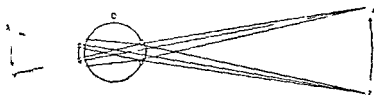
Fig 279 —Showing the course of incident rays and field of illumination of the fundus in hypermetropia l_1 forms a virtual image at λ_1, l_2 at λ_2 The field of illumination is determined by the pupil of O_1

Again, consider the rays of rays reflected from the illuminated area on the fundus of a highly myopic eye   They will be convergent and will cross at a real point in front of the eye This far point, corresponding with the illuminated area, will move upwards when the illuminated area moves downwards An observer placed in front of the eye and farther from it than the far point if he looks towards the far point but accommodates for the observed pupil will see a circle of light with a blurred margin   When the illumination on the retina moves
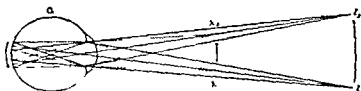
Fig 280 —Showing the course of incident rays in myopia

down, the circle of light which the observer sees will move up, i e , in the opposite direction to the movement in the case of the hypermetropic eye (Fig 280)
    Now suppose that the observer's eye is one metre in front of the observed eye, and that the latter has 1 D of myopia In this case the far point of the observed eye will be at the situation of the observer's eye, say at the level of his pupil (Fig 281)   In this case a very slight movement of the light

on the observed fundus will throw the image at the far point off the observer's eye altogether In other words, the observed pupil will appear to be completely bright or completely dark.

If, again, the observed eye is emmetropic, its far point will be at infinity We may regard it as being infinitely far behind the observed eye Here, again, there will be scarcely any shadow, though in reality there is a very faint shadow moving in the same direction as for the hypermetropic eye

The above is a simple explanation of the theory of retino scopy The question of the type of mirror is an entirely subsidiary one It merely has to do with the direction of movement of the immediate source of light, i e , the point of light in front of the eye which has been considered above The image of a real light behind the patient's head formed by a concave mirror is situated in front of the mirror If the
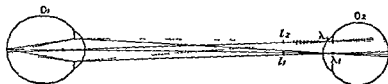
FIG 281 —Showing the course of the emergent rays at the point of reversal So long as λ_1 is in the pupillary area of O_2 the pupil of O_2 appears uniformly illuminated, and there is no shadow Directly λ_1 passes to λ_2 the whole of the light is cut off so that the pupil of O_1 becomes completely dark

mirror is tilted up, the image moves up The image of a real light behind the patient's head, formed by a plane mirror, is situated as far behind the mirror as the light is in front of it When the mirror is tilted up, the image moves down

Hence under the actual conditions of retinoscopy with a plane mirror, when the mirror is tilted to the right the imme diate source of light moves to the left and—

(a) In the hypermetropic eye the circle of light on the fundus moves to the right, and the shadow seen in the pupil moves to the right

(b) In the myopic eye (above − 1 D) the circle of light on the fundus moves to the right, and the shadow seen in the pupil moves to the left ,

(c) In the myopic eye of − 1 D there is no shadow,

(d) In emmetropia and myopia of less than − 1 D there is a very faint shadow moving to the right

Stated as a mere guide to practice, with the plane mirror the shadow moves in the same direction as the mirror in

hypermetropia and in the opposite direction in myopia above one dioptre; in myopia of one dioptre there is no shadow and in emmetropia and myopia of less than one dioptre there is a very faint shadow moving in the same direction as the mirror.

In actual retinoscopy the whole of the image of the illuminated area of fundus cannot be seen at once; the shadow is part of the circumference. In high degrees of ametropia the shadow has a distinctly curved border, it is very dark, and it moves very slowly (Fig. 282). In low degrees of ametropia the border of the shadow looks straight; it is faint, and it moves very rapidly.

The movement of the shadow, being a purely optical phenomenon, is, of course, independent of the cause of the ametropia. Consequently, in astigmatism, if one axis is hypermetropic and the other myopic (mixed astigmatism) the shadow moves in

Fig. 282

opposite directions in the two meridians. Often the periphery of the cornea is flatter than the centre; correction of the refraction of the central part, which is the more important, will then differ from that of the peripheral part. These variations produce very puzzling shadows in many cases.

Retinoscopy is applied to the estimation of refraction by placing correcting lenses in front of the eye and noticing the effect upon the shadow. When the shadow has completely disappeared we know that the eye has been made myopic D 1 if the surgeon is at one metre from the patient.

Retinoscopy is conducted in a dark room. The light is placed behind and above the patient's head. The surgeon sits at one metre from the patient. The patient wears a trial frame; the eye not under observation is covered by a screen. A mydriatic should be used by all but skilled observers, and is necessary to them in many cases. A plane mirror should be used. The patient looks at the observer's forehead.

The light is reflected into the eye, and the mirror is slowly tilted from one side to the other. The direction in which the shadow moves is noted. The horizontal meridian should be observed first, then the vertical. If the shadow appears to swirl round, not moving in the same meridian as the mirror, the eye is astigmatic, and the mirror is not moving in a direction which corresponds with either axis. A direction of move-

ment can then be found in which the shadow will move either directly with or against the mirror , this is one of the principal axes of the astigmatism The other axis is at right angles (regular astigmatism)
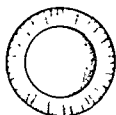
If the shadow moves with the mirror a low convex glass is put in the frame in front of the eye If the shadow still moves in the same direction a stronger convex glass is used and so on until no shadow can be seen A still stronger convex glass is placed in the frame The shadow now probably moves against the mirror We now know that the refraction has been over corrected The point at which there is absolutely no shadow—the point of reversal—is somewhere between the last two lenses and we know that at that point the refraction of the eye *plus* the lens is equivalent to one dioptre of myopia If for example, the shadow can still be seen to move with the mirror with + 4 D lens in the frame and moves against it with + 5 D, we shall not be far wrong in considering that the point of reversal is + 4 5 D A + 4 5 D lens would therefore make the eye one dioptre myopic The actual refraction is therefore + 3 5 D If there is no astigmatism the patient ought to be able to read 6/6 with this lens If he is under atropine
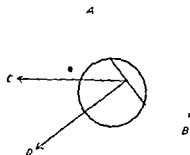
Fig 283

a further correction must be made before glasses are ordered Atropine not only paralyses the ciliary muscle, but also inhibits the physiological tone of the muscle This is found by experience to be equivalent to about 1 D of accommodation Hence the glass which should be ordered to correct the distant vision after the mydriatic has passed off is + 2 5 D

Similarly for spherical myopia Supposing — 4 D eliminates the shadow against the mirror and — 4 5 D gives a distinct shadow with the mirror we know that — 4 25 D will leave the eye with still — 1 D Hence the refraction under atropine is — 5 25 D The correction for atropine gives — 6 25 D as the lens which corrects distant vision without a mydriatic The tone of the ciliary muscle is often less in myopia than in hypermetropia since myopia should be under- rather than over-corrected, it is wiser to order very little more than the atropine correction, e g , 5 5 D in the above example

In astigmatism each principal meridian is corrected separately When one meridian is approximately corrected the shadow assumes the shape of a band The edge of the band is parallel to the axis of the corrected meridian Even if the light is not moved in a direction accurately at right angles to this meridian the shadow still seems to move in the same direction This is due to an optical illusion If a straight edge A B is placed obliquely behind a circular hole in a card and is then moved horizontally in the direction of the arrow C it will appear to be moving in the direction of the arrow D at right angles to its own edge (Fig 283) The shadow is most sharply defined if the mirror is moved at right angles to its edge *i e* at right angles to the corrected meridian

The results are usually recorded thus (Fig 284) the directions of the lines indicating the directions of the axes —

The numbers should represent what the surgeon believes to be the refraction of the eye under the mydriatic, not numbers
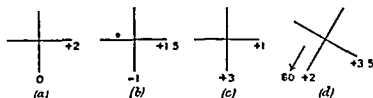
FIG 284

to which further modifications have to be made *e g*, the actual lenses used In the examples given (*a*) is a case of regular simple hypermetropic astigmatism according to the rule (*b*) regular mixed astigmatism according to the rule, (*c*) regular compound hypermetropic astigmatism against the rule (*d*) regular compound hypermetropic astigmatism with oblique axes The exact direction of the axis in astigmatism is usually determined by subjective trial In children it may be found by placing the requisite cylinder in the trial frame and rotating it until no shadow can be observed in any direction In the examples given the correcting lenses required would be (*a*) + 2 D cylinder, axis vertical, (*b*) — 1 D sphere combined with + 2 5 D cylinder axis vertical or + 1 5 D sph $\bigcirc$ — 2 5 D cyl axis horizontal, (*c*) + 1 D sph $\bigcirc$ + 2 D cyl axis horizontal or + 3 D sph $\bigcirc$ — 2 D cyl, axis vertical, (*d*) + 2 D sph $\bigcirc$ + 1 5 D cyl axis 60° down and in or down and out, according as it represents the left or the right eye

To avoid ambiguity in ordering glasses the axes of cylinders should be uniformly numbered according to the method commonly used by British opticians (Fig 285)
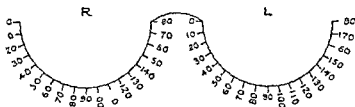
Fig 285 —Standard numeration of areas of cylinders

The shadows in regular astigmatism are not always easy to correct, owing chiefly to differences in curvature of different parts of the cornea Usually the periphery of the cornea is flatter than the centre The centre of the pupillary area will then be corrected by a different lens from the periphery, especially with the dilated pupil From this cause various conflicting shadows may be seen, the commonest being the so-called "scissors" shadows, where two shadows appear to meet each other and cross as the light is moved in a given direction (Fig 286) These difficulties are diminished with the undilated pupil and an experienced retinoscopist can obtain reliable results under these conditions with an intelligent patient Relaxation of the patient's accommodation without a mydriatic is best obtained if the retinoscopy is done in a large dark room and the patient is told to look "right across the room"

Fig 286

In conical cornea a triangular shadow with its apex at the apex of the cone, i e , usually slightly below the centre of the cornea, appears to swirl round its apex as the mirror is moved
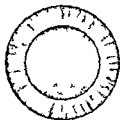
Retinoscopy is most valuable in determining accurately the amount of astigmatism, i e , the difference between the two meridians

In irregular astigmatism the shadows move in various directions in different parts of the pupillary area, they cannot be accurately corrected by spherical or cylindrical lenses, but some improvement of vision may be obtained

In conclusion, a word of warning must be given The correc

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tion of a given refraction by retinoscopy may be very easy or
very difficult   A vast number of refractions should have
been carefully corrected and confirmed by subjective tests
before a surgeon should consider himself justified in ordering
glasses without supervision from an expert

CHAPTER XXIV

Errors of Refraction

Myopia, or "short sight," is that dioptric condition of the eye in which, with the accommodation at rest, incident parallel rays come to a focus anterior to the light-sensitive layer of the retina   Myopia may be due theoretically to any of the following conditions—*A* Abnormal length of the eye—*axial myopia*   *B* Abnormal curvature of the refracting surfaces—*curvature myopia*   (a) too strong curvature of the cornea, (b) too strong curvature of one or both surfaces of the lens   *C* Abnormal refractive indices of the media—*index myopia*   (a) too high index of the cornea or aqueous, (b) too high total index of the lens, due to (a) too high index of the nucleus, (β) too low index of the cortex, (γ) both these causes, (c) too low index of the vitreous   *D* Abnormal position of the lens, i e , displacement forwards   *E* A combination of the above abnormalities

It has been proved that emmetropic eyes may differ in length by as much as 1—2 mm , and that the radius of curvature of the cornea may vary from 7—8 mm   Emmetropia therefore results from the integration of all the variables mentioned in the previous paragraph   Statistically one might expect its incidence to resemble the Gaussian frequency curve, but since the full development of emmetropia is never present normally at birth the curve will have a certain ' skew deviation '   Almost inevitably some cases will fail to reach emmetropia and remain hypermetropic, while others will proceed too far and become myopic   Of these the former are by far the more numerous   I am of opinion that many cases of low myopia come under this category   They cannot in the true sense be regarded as pathological, and they may be expected to remain permanently unprogressive (*developmental myopia*)   I have observed many cases of low myopia, with normal fundi, which have remained stationary for many years

There is no question that increased length of the eye is the most important factor in the high degrees   It is not improbable that the other factors are of more importance than is commonly thought in the lower degrees   Curvature myopia is

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occurs commonly as a factor in astigmatism, but is rare as a
cause of spherical myopia, and is then associated with disease
of the cornea—conical cornea   Index myopia is seldom seen
clinically, but it accounts for myopia as a premonitory symptom
of senile cataract, when it is due to increased refractive index
of the nucleus of the lens , it also accounts for myopia in some
cases of diabetes, with or without cataractous changes in the
lens

The increase in length of the eye affects the posterior pole
and the surrounding area , the part of the eye anterior to the
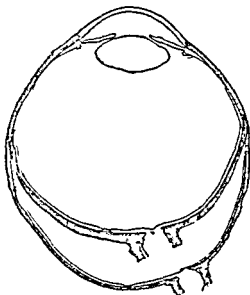
Fig 287—Horizontal sections of emmetropic and myopic eyes from
the same patient superposed showing the identity of the pre-equatorial
regions   (Heine)

equator may be absolutely normal (Fig 287)   In most cases
the myopia is of low degree, i e , up to 5 or 6 D (simple myopia)
Less commonly the error reaches a considerable degree in child
hood or early youth and increases steadily up to twenty five or
more finally amounting to 15 to 25 D or more (*progressive
myopia*)   It is impossible clinically or pathologically, to draw
a distinct line of demarcation between the two forms

In low myopia the only symptom may be indistinct distant
vision   In other cases and in high myopia there is often in
addition, discomfort after near work, due largely to dispro-

portion between the efforts of accommodation and convergence (*vide* p. 546). The eyes are unduly sensitive to light. Black spots are seen floating before them, and sometimes flashes of light are noticed; the latter may occur irrespective of any tendency to detachment of the retina (*vide* p. 379). In very high myopia the eyes are prominent, the pupils are large, and the anterior chamber appears deeper than normal, probably only owing to the dilatation of the pupil. There may be an apparent convergent squint due to a large negative angle γ (*vide* p. 568). A true divergent strabismus may be found, either concomitant or affecting only

FIG. 288.

FIG. 289.

FIG. 288.—Diagrammatic horizontal section of normal disc
FIG. 289.—Diagrammatic horizontal section of myopic disc N, nasal
side; T, temporal side, P Pigment, retinal pigment epithelium,
R, retina, Ch, choroid, Scl, sclerotic (Modified from Heine)

one eye. Vision may be very poor, even with correction; scotomata may be present, both central and peripheral.

Ophthalmoscopically, in low myopia there may be a quite normal fundus; the optical defect will of course be noticed, especially on examination by the direct method. In the majority of cases of moderate myopia there is a "myopic crescent" (Plate XVIII., Fig. 2) This is a white crescent at the temporal border of the disc, very rarely it is nasal. In higher degrees of myopia it may extend to the upper and lower borders, or a complete ring may be formed round the disc. The crescent is occasionally absent even in cases of high myopia.

The bulging at the posterior pole in high myopia is called a posterior staphyloma. It is distinguishable clinically only

by its optical and pathological effects The term should not
be used as a synonym for myopic crescent as is often done
Optically posterior staphyloma causes the high error of
refraction, and the edges may be actually visible by the
indirect method owing to the presence of a crescentic shadow
two or three disc diameters to the nasal side of the disc and
concentric with it and to the change in course of the retinal
vessels (staphyloma posticum verum) Pathologically, pos-
terior staphyloma causes degenerative changes in the choroid
and overlying retina   these are commonly described as
"myopic choroiditis," but this term should be abandoned
since the condition is non inflammatory and should be called
myopic choroido-retinal atrophy   The changes are generally
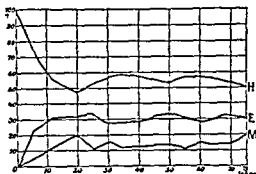
Fig 250 — Age incidence of ametropia   (Herrnheiser)
Ordinates percentages, abscissæ, ages

limited to the posterior pole and the surrounding area
(Plate XVIII , Fig 2) Small yellowish, white, or pigmented
spots, and not infrequently white branched lines, usually
horizontal are found at and around the macula The spots
coalesce, forming irregular areas which may extend to the
disc. Patches of choroidal atrophy are common near the
disc , they may fuse with each other and with the myopic
crescent so as to form a ring round the disc Small foci occa-
sionally occur at the periphery Hæmorrhages in the macular
region are generally described in high myopia I believe them
to be rare , the appearance of small hæmorrhages is very
nearly simulated, but the spots undergo no change for an
indefinite time , they are probably due to bunches of dilated
capillaries, usually choroidal, rendered visible by rarefaction
of the retinal pigment layer. The retinal pigment epithelium
often loses much of its pigment in high myopia, so that the

fundus is tigroid and the choroidal vessels are well seen, this condition is not inconsistent with good vision

Black specks in front of the eyes are often complained of in myopia Dusty vitreous opacities may be visible with the ophthalmoscope (*vide* p 110), or in high myopia large floating streamers The normal muscæ volitantes are seen more plainly by myopic than by other eyes, probably because the entoptic image is generally larger

A rare, but serious, change in the fundus is a small circular claret coloured or black spot at the fovea It may appear quite suddenly, being accompanied by great diminution of central visual acuity it is probably due to intrachoroidal hæmorrhage or thrombosis

Detachment of the retina is liable to occur spontaneously in about 5 per cent of cases of high myopia, and not infrequently is bilateral (*vide* p 378)

Ætiology Myopia is rare in the new-born, the percentage of cases increasing rapidly during the first two decades, remaining constant afterwards at 10 to 15 per cent, as compared with 30 per cent for emmetropia and 50 to 55 per cent for hypermetropia (Fig 290) As regards sex, there is no doubt that the higher grades are commoner in women than in men High myopia is as common among peasants as among the educated classes who do more near work It is doubtful if near work is a cause of myopia, a view which has been held since the time of Kepler There is however, no doubt that it has a deleterious influence upon the disease This has been attributed by Donders to (*a*) pressure of the extrinsic muscles upon the globe in strong convergence, (*b*) increased intraocular pressure from vascular congestion, due to the position of the head, (*c*) congestion of the fundus, leading to softening of the tissues Accommodation has long been indicted as a cause of myopia Many facts are against this view, e g, (*a*) accommodation occurs much more forcibly in hypermetropia, (*b*) it does not increase the intraocular pressure, (*c*) it does not affect the choroid farther back than the equator. and does not affect the sclerotic at all

The mechanism whereby convergence influences the production of myopia is the subject of many theories, e g, pressure on the vortex veins, increased intraocular tension and so on

Neither accommodation nor convergence alone suffices to explain the genesis of myopia There must be some individual predisposition which provides any such accessory causes with advantageous conditions There is probably a congenital

weakness of the sclerotic Other theories invoke shortness of the optic nerve (certainly false) special conformation of the skull leading to increased interpupillary distance or alteration in the position of the pulley of the superior oblique &c The view that moderate and high myopia are essentially distinct diseases due to different causes is probably untrue

The cause of the myopic crescent has given rise to much discussion It is probably congenital in origin allied to other congenital crescents (*vide* p 401) but there is no doubt that it may become altered by the conditions obtaining in the myopic eye Anatomically there is considerable distortion of the papilla in myopia It has been attributed to dragging produced by the development of the posterior staphyloma, whether caused thus or not it is an influential factor Some authors ascribe the crescent to this cause (distraction crescent) In well marked cases the head of the nerve is pulled over to the temporal side The retina including the pigment epithelium, is pulled slightly over the nasal edge of the disc (supertraction crescent) On the temporal side the pigment epithelium stops short at a variable distance from the disc and the choroid is atrophic here (Fig 289) This part appears ophthalmoscopically as the crescent

The fact that the crescent may be absent in high myopia and is often present in low militates against the view that it is caused entirely by traction It is not due to accommodation for the same reasons that myopia is not caused by this factor

As regards *prognosis* low or moderate degrees of myopia (up to 5 or 6 D) unless occurring in young children have a good prognosis (*vide* p 517) They are not likely to progress, and in some of the conditions of civilised life they may even be an advantage to the individual The same condition in a child before the age of schooling is of grave prognosis, because it is almost certain to progress so that in a few years there may be 10 or 15 D of myopia accompanied by serious fundus changes and defects of vision The prognosis in high degrees of myopia is always grave It must be judged by the acuity of vision after correction and the condition of the fundus In all cases there is some danger of retinal detachment occurring

Treatment consists in wearing suitable correcting glasses and attention to the hygiene of the eyes Each case must be considered on its merits

As regards the ordering of glasses in myopia every surgeon agrees that *myopia must never be over-corrected* Opinions differ as to details In low myopia, up to 5 or 6 D (young

children excepted) no harm is done by ordering the full distant correction for constant use, but if this is done the patient must be warned not to hold near work closer than ordinary reading distance. Many surgeons order glasses weaker by 2 or 3 D for near work. This has the effect of making the patients artificially presbyopic, i.e., if they hold the work at reading distance they exert 2 or 3 D less accommodation than an emmetropic person would do, or than they themselves would do if wearing full correction. Many patients are more comfortable for near work with the weaker glasses, others find no benefit. There is no doubt that the principle is derived from the fallacy that accommodation, *per se*, has a deleterious effect upon myopia. But there are some inherent objections to the weaker glasses. The patients often bring their work closer than reading distance. As far as accommodation is concerned this matters less with the weak glasses than with the strong but mere accommodation is of little importance. It is convergence which is the important factor. In order to read at reading distance there must be some convergence. If the artificial presbyopic correction is given no stimulation to converge is supplied by the act of accommodation, so that in order that physiological requirements may be satisfied the visual axes should be parallel. This can only be effected by combining the glasses with prisms, bases in (*vide* p. 547). If the work is held too near still more convergence is required, and the arguments apply still more strongly.

In general, in low myopia, the full correction may be ordered for constant use, with minute instructions as to near work; in the event of any discomfort being experienced, weaker glasses should be ordered for near work especially if much reading and sewing, &c., is engaged in. Children should wear their distance corrections, and wear them constantly—not specially in the interests of their eyes but in the interests of their mental development. For children with even low degrees of uncorrected myopia cannot be expected to take a normal interest in their surroundings, since they cannot see distant objects as clearly as their fellows. Their mental horizon is constricted, they tend to become unduly introspective, and they are thrown more and more into finding their interest in reading and near work, so that it becomes more difficult than ever to restrict such work.

In young people with intermediate grades of myopia it is well to err on the safe side and order a slight under correction

In such cases, however, the patients will often peer obliquely through the glasses, which improves the definition in spite of the astigmatic effect of tilting strong lenses

In high myopia it is wise always to slightly to under-correct even for distance, and the same or still weaker glasses may be ordered for near work. In the highest grades the patient often sees best with glasses which are decidedly weaker than the full correction, he should be allowed to choose those he prefers One reason is that the strong minus glasses very markedly diminish the size of the retinal images and make them very bright and clear. The retinal images are diminished because the glasses have to be worn farther from the eye than the anterior focal plane (*vide* p 42), glasses for high myopia should therefore be made to fit as close to the eyes as possible toric lenses may be ordered, or the eyelashes cut in order to prevent them from rubbing upon the glass. The very bright, clear images are uncomfortable because the retina is unduly irritable, probably owing to the fact that it has become accustomed to large indistinct diffusion images Moreover, much artificial astigmatism, and therefore distortion of the image, is produced by looking obliquely through strong glasses, it is found to be most disconcerting to those who begin the use of glasses or have them much strengthened late in life. Very short-sighted people get into the habit of turning the head rather than the eyes to avoid looking obliquely through the glasses. Some high myopes can find their way about much better without any glasses. Contact glasses afford relief in cases where they can be borne

In very high myopia the requisite amount of convergence for near work may be impossible. Reading and other near work then becomes purely uniocular. Generally one eye is better than the other, and this eye is always used. The effort to maintain convergence under impossible conditions is soon given up, which results eventually in the disused eye becoming divergent. There are other factors which tend to cause divergent strabismus in myopia (*vide* p 581)

As regards hygienic measures in myopia, especially in the young near work, apart from being held in the proper position, must be restricted. It is particularly important that it should not be done too continuously. More work can be done, with less harm to the eyes, by the interpolation of frequent short intervals of rest. It is best to give precise instructions as to the amount and distribution of near work. The illumination must be good, but not too bright, and it

should come from behind and beside the patient's head If the light is bad there is a strong tendency to bring the book or work closer to the eyes in order to enlarge the retinal image Reading in bed and stooping over near work must be forbidden

The education of young children suffering from myopia presents considerable difficulty Most of the teaching is oral, the school books are printed in large characters, and writing is taught with bold letters on a blackboard The methods adapted in the London County Council "myope classes" are admirable for the higher degrees, but are liable to be overdone by enthusiasts Great judgment is needed in the restriction of near work in school children with 8 to 10 D of myopia They are often unusually intelligent, and it must be realised that extreme measures such as abstention from all near work for two or three years, may ruin their future careers

If the eyes are irritable, or the myopia is progressing, complete rest is imperative Atropine should be instilled once a day for a prolonged period, tonics, especially iron and arsenic, should be given, and a change of air to the country, with plenty of healthy exercise, is desirable Excessive muscular exercise, straining, and lifting heavy weights should be avoided

Operative treatment for high myopia If an eye has axial myopia of 24 D, its length will be about 31 mm (*vide* p 530) If the crystalline lens of such an eye is removed, parallel rays will be focussed upon the retina without the intervention of any correcting lens, and the retinal images of distant objects will be larger than those of the emmetropic eye Hence the extraction of the lens has been strongly advocated in high myopia In completely successful cases the improvement is very great The operation is, however, attended with grave dangers The eye with high myopia is a diseased eye, which withstands operative measures badly The vitreous is likely to be fluid and to contain opacities The retina and choroid are probably diseased, and the tendency to detachment of the retina is increased by operation No dogmatic rules can yet be given for the operation I am guided by the following principles (1) Only young patients should be operated upon, (2) the operation should be discission without subsequent curette evacuation unless it becomes imperative on account of tension, (3) there must be at least 15 D of myopia, (4) the fundus must be fairly healthy, (5) one eye only must be operated upon The operation may be performed under less favourable circumstances if vision is so bad as to be useless, but such cases are rare

Hypermetropia (*Syn—Hyperopia*), or "far sight," is that dioptric condition of the eye in which, with the accommodation at rest, incident parallel rays come to a focus *po terior* to the light sensitive layer of the retina Hypermetropia may be due theoretically to any of the following conditions —*A* Abnormal shortness of the eye—*axial hypermetropia B* Abnormal curvature of the refracting surfaces—*curvature hypermetropia* (*a*) too slight curvature of the cornea, (*b*) too slight curvature of one or both surfaces of the lens *C* Abnormal refractive index of the media—*index hypermetropia* (*a*) too low index of the cornea or aqueous, (*b*) too low total index of the lens due to (*a*) too low index of the nucleus, (*β*) too high index of the cortex, (*γ*) both these causes, (*c*) too high index of the vitreous *D* Abnormal position of the lens, *i e* displacement backwards *E* Absence of the lens—*aphakia* *F* A combination of the above abnormalities

As in myopia, the chief factor in clinical hypermetropia is abnormality in the length of the eye , in this case the eye is too short It must be remembered that a small eye, though too short is not necessarily hypermetropic, since there may be uniform diminution of all the parts This is perhaps, most easily understood if a diagram such as Fig 29 is considered , if such a diagram is uniformly diminished, *e g* , by photography, the parallel rays will still come to a focus on the retina As a matter of fact hypermetropic eyes are almost invariably also smaller than normal a fact which is of great pathological importance (*vide* p 283)

Curvature hypermetropia occurs commonly as a factor in astigmatism it is almost unknown as a cause of spherical hypermetropia Index hypermetropia accounts for the hypermetropia of old age (*vide* p 53) and it is to be attributed to increased refractive index of the cortex of the lens

Hypermetropia rarely exceeds 6—7 D, which is equivalent to a shortening of the optic axis of 2 mm Individual cases of much higher degrees, without other anomaly, such as coloboma or microphthalmia, have been recorded—up to 24 D

In the young the condition may cause no symptoms When symptoms are present or arise they are chiefly referable to the abnormal amount of accommodation to which these eyes are subjected and to the lack of consonance between accommodation and convergence (*vide* p 546) As has been pointed out the healthy youth has an ample reserve of accommodation, and if he happens to be hypermetropic he accommodates for distant and near objects without being conscious of the act

If he is weakly or does much near work the perpetual overaction of the ciliary muscle is likely to produce symptoms, the condition is often called accommodative asthenopia or "eye-strain" The symptoms are noticed chiefly after reading, sewing &c, especially in the evening by artificial illumination The eyes ache and burn, they may feel dry, so that blinking movements are more frequent than usual or there may be lacrymation The conjunctiva and edges of the lids become red, and actual blepharitis may be caused If near work is persisted in head ache usually frontal comes on Typical migraine may occur

In young children hypermetropia is a predisposing cause of convergent strabismus (q v) In all cases latent convergence is often found in hypermetropes though other forms of heterophoria may occur (*vide* p 587) The presence of heterophoria increases the tendency to headache &c

In older patients no symptoms may be caused until the power of accommodation has diminished to the extent that the far point is beyond the range of comfortable reading distance Near work has to be held farther off than usual in order to be seen clearly The greater the degree of hypermetropia the sooner will this symptom arise In other words apparent presbyopia commences at an earlier age than usual It must be carefully borne in mind that hypermetropia predisposes to glaucoma (q v) in elderly people

Ophthalmoscopically the fundus may exhibit no abnormality A bright reflex, suggesting the appearance of watered silk, is commoner in hypermetropic than in emmetropic or myopic eyes The inferior crescent is also more common in these eyes than in others as also abnormal tortuosity of the retinal vessels In some cases optic neuritis is nearly simulated—pseudo papillitis (*vide* p 390)

Anatomically the eye is shorter than normal in hypermetropia it is also usually smaller The changes are not confined to the post equatorial segment as in myopia The diameter of the cornea is often reduced and regular astigmatism is common The anterior chamber is shallower than normal owing partly to the normal size of the lens (*vide* p 283) Little weight should be attached to the old observation that the circular fibres of the ciliary muscle are hypertrophied, the meridional atrophied in hypermetropia No anatomical abnormalities are found in the retina choroid or optic nerve

The new born are almost invariably hypermetropic (mean 2 5 D) In the first decades of life the hypermetropia curve

falls rapidly, remaining at about 50 per cent after the twentieth year (Fig 290) Hypermetropia shows no predilection for either sex It is a well known fact that savages are usually hypermetropic The higher mammals especially the carnivora are hypermetropic

Treatment consists in prescribing the correcting glasses Unless there are definite symptoms there is no reason for insisting upon the use of glasses in the young or middle aged In elderly people the hypermetropia must be corrected for near work the ordinary presbyopic correction must be added to the hypermetropic correction but care should be taken that these cases are rather under than over corrected (*vide* p 531)

In young children the requisite correction is estimated under atropine confirmed if possible by subjective tests The correction allowing for the effect of atropine upon the tone of the ciliary muscle (*vide* p 513) is ordered for constant use or only for near work according to the severity of the symptoms If the degree of hypermetropia is high the use of the glasses may be commenced while the child is still under the influence of atropine In older patients with high hypermetropia it is often unwise to order the full correction at once The ciliary muscle has been overworked so long that complete relaxation does not occur immediately If the full correction is ordered the eye with its contracted ciliary muscle *plus* the glass is made myopic the patient cannot see clearly at a distance and is liable to discard the spectacles In these cases rather more than the amount of manifest hypermetropia should be ordered The patient is told to return in three or six months when stronger glasses are ordered and so on until the full correction can be borne with comfort

Astigmatism is that condition of refraction in which a point of light cannot be made to produce a punctate image upon the retina by any spherical correcting lens The varieties of regular astigmatism have been already enumerated (*vide* p 46)

Regular astigmatism the only form which permits of optical correction invariably produces greater or less defect in visual acuity It is particularly liable to cause the worst forms of asthenopia or eye-strain the asthenopia in these cases is only in part accommodative It is often worse in the lower degrees of astigmatism than in the higher This is probably due to the eye endeavouring so to accommodate as to produce a circle of least diffusion (*vide* p 46) upon the retina Aching of the eyes severe headaches and typical migraine are com

plained of, the eyes quickly become fatigued with reading, and the letters are described as "running together"

Regular astigmatism is usually a congenital defect due in most part to difference in curvature of the cornea in different meridians It must be remembered that frequently the cornea is not alone at fault Corneal astigmatism may be increased or partially corrected by lenticular astigmatism hence the methods for correcting astigmatism, such as the ophthalmometer, &c, which are wholly dependent upon estimation of the corneal defect, are quite untrustworthy except in aphakia

Regular astigmatism may be traumatic, following a wound, usually surgical, in the corneo scleral margin The contraction of the scar causes flattening of the cornea in the meridian at right angles to the wound The astigmatism due to this cause continues to alter for many weeks after the injury, so that glasses should not be ordered for at least six weeks

The higher degrees of astigmatism cause much lowering of visual acuity this is usually least in mixed astigmatism, probably because the circle of least diffusion falls upon the retina

Treatment In all cases in which astigmatism causes asthenopic symptoms the full correction should be ordered for constant use, i e, both for distant and near vision If there is a high degree of hypermetropia or myopia, associated with a low degree of astigmatism, the effect of the cylinder upon distant vision should be tested If it produces no appreciable improvement simple spherical glasses should be tried first It should be remembered that glasses placed before the eyes only correct the refraction accurately when the visual axis passes through the optical centre of the lens When the eyes are directed to one side the lenses also act as prisms, and further the lenses are tilted relatively to the eyes so that an astigmatic effect is produced In the case of high spherical lenses the astigmatic effect is considerable, and may easily counteract or double the effect produced by a weak cylinder combined with the sphere Hence weak cylinders are seldom of much use when combined with high spheres

In low astigmatic errors the instruction as to the use of glasses depends upon the amount of asthenopia The relief of the discomfort experienced may not be worth the trouble of wearing glasses constantly In these cases they should be ordered for near work only, and if this fails to eliminate the symptoms the advice should be given to wear them constantly

Aphakia is the condition of the eye when the crystalline lens has been removed   The eye is extremely hypermetropic if it was emmetropic or had only a low grade of ametropia before removal of the lens   The hypermetropia, as estimated by the correcting lens required when worn in the usual position, is about 10 or 11 D if the eye was previously emmetropic.

The optical conditions of the aphakic eye are very simple   It consists of a curved surface, the cornea, separating two media, air and vitreous of different refractive indices   Knowing the radius of curvature (8 mm) and the refractive indices (1 and 1 33), it is easy to calculate the focal distances   The anterior focal distance is 23 mm and the posterior 31 mm, as compared with 13 mm and 23 mm respectively for the normal eye   If the aphakic eye were 31 mm long parallel rays falling on the cornea would be brought to a focus on the retina and no correcting glass would be required for distance   It is easy to calculate the amount of axial myopia of a phakic eye which is 31 mm long   It has been already pointed out that in the phakic eye 1 mm of elongation is equivalent to an axial myopia of 3 D   Therefore an elongation of 31 − 23 mm , i e , 8 mm , equals 24 D (*vide* p 525)

The retinal image of the aphakic eye is about one third as large again as the emmetropic retinal image   Hence vision of 6/6 with a correcting glass after extraction is not quite so good as it seems

Accommodation is, of course, lost   The anterior chamber is deep, the iris tremulous, and there is often a coloboma of the iris upwards   In cases of doubt as to the absence of the lens the Purkinje-Sanson reflexes from the lens surfaces should be sought

With the ophthalmoscope opacities will probably be found in the pupillary area consisting chiefly of remnants of the lens capsule   They should be examined by oblique illumination, by the mirror and by the direct method   If they are dense, discussion is indicated before attempting to correct the refrac tion , if they are slight, the advisability of needling depends upon the amount of vision obtained with correction

In addition to the hypermetropia, there is always some astigmatism in those cases in which a corneal or corneo-scleral section has been made   If the section is in the upper part of the cornea, the astigmatism is against the rule , i e , the cornea is flattened in the vertical meridian   The astigmatism usually amounts to 2 or 3 D   It gradually diminishes, fairly quickly at

first and very slowly after the first few weeks, as the cicatricial tissue in the scar contracts

Treatment   The refractive error is determined by retinoscopy and by subjective tests   The ophthalmometer may afford help in these cases   Great patience is often necessary, for the patients do not readily accommodate themselves to the new optical conditions   A 10 or 11 D convex lens combined with a + 2 or + 3 D cylinder, axis horizontal, is about the correction usually required for distance   It should be remembered that the lens in the trial frame is usually farther from the eye than in well fitting spectacles   With these strong lenses an appreciable error is introduced, and the spheres ordered should be 0 5—0 75 D stronger than those which give the optimum result with the trial frame   The sphere must be stronger by 4 D for near work   A small amount of false accommodation can be obtained by slightly altering the distance of the glass from the eye   The correcting glasses should not be ordered earlier than six weeks after the operation, both on account of the necessity of resting the eye and because the astigmatism changes rapidly during the first few weeks

If one eye only has been operated upon, the other being cataractous, reversible spectacle frames may be ordered   In them the bridge is horizontal, so that when the distant glass is being used the near glass is in front of the eye which has not been operated upon, and *vice versâ*   Reversible frames, however, never fit very satisfactorily

The aphakic eye is specially liable to erythropsia (*q v*) and should therefore not be exposed to very bright light

Anisometropia is the condition in which the refraction of the two eyes shows a considerable difference   A slight difference is very common   The condition may cause asthenopic symptoms   All varieties and degrees of anisometropia occur   In the lower grades there is usually binocular vision, though it is imperfect   In the higher grades this is impossible without correction   Distinct vision is then uniocular, and there is some danger of the eye which is not used becoming divergent   If one eye is nearly emmetropic and the other myopic, the former may in some cases be used for distant, the latter for near vision

Treatment   Correction of anisometropia offers many difficulties   It has already been mentioned that if correcting glasses are placed at the anterior focal plane of the eye, the retinal images in axial ametropia are the same size as the emmetropic retinal image   In practice the glasses are farther

from the eyes Consequently with convex glasses the retinal image is enlarged with concave diminished In high grades of anisometropia, therefore, there will be a considerable difference in the size of the retinal images of the two eyes (*anisetdonia*) Patients find it difficult or impossible to fuse these sharp but diverse images Moreover, on looking obliquely through the glasses the prismatic effect and the distortion are different in the two eyes enhancing the discomfort Contact glasses diminish these optical effects and may be ordered in suitable cases

No universal rules can be given for the glasses which should be ordered The following suggestions will generally be found to work well If the difference between the two eyes is less than 4 D, the full correction should be ordered for constant use, they should be perseveringly worn for at least six weeks If still they cannot be borne, it will probably be necessary to correct only the less ametropic eye for distance

In patients of less than twelve years of age the full correction should also be ordered for constant use, even if the difference is greater than 4 D The more ametropic eye should be exercised alone as in cases of concomitant strabismus (*vide* p 577) Very often the treatment will fail, but it should be tried in the interests of binocular vision It is almost certain to fail in older patients

When the full correction cannot be worn constantly and one eye is myopic, both eyes can often be made to work together in comfort for near work by making each eye artificially presbyopic to the extent of half the difference between the two eyes For example suppose one eye is emmetropic and the other has 3 D of myopia the patient will be most comfortable with + 1 5 D in front of the emmetropic, and − 1 5 D in front of the myopic eye for near work

THE CORRECTION OF ERRORS OF REFRACTION

The correction of errors of refraction has been already briefly sketched It will be well however to outline the method to be adopted in systematically examining for and correcting these errors and to indicate the requirements which should be satisfied by spectacles

If the patient is less than fifteen years of age —

(1) Test the distant and near vision if the child knows his letters

(2) Test the pupil reactions ,

(3) Test the muscular balance by the screen test (*vide* p 550),

(4) Examine the fundi with the ophthalmoscope

Then order ung atropinæ, 1 per cent, to be inserted with a glass rod, three times a day for at least three days

At the next visit—

(1) Determine the error of refraction by retinoscopy,

(2) Thoroughly examine the fundus with the ophthalmoscope,

(3) Confirm the retinoscopy by subjective tests, if the child knows his letters,

(4) Order the correction according to the principles enunciated in the paragraphs devoted to the respective types of refractive error

If the patient is between fifteen and twenty five years of age, the same procedure should be adopted, but in many cases the prolonged action of atropine so seriously interferes with the patient's employment that it may be replaced by homatropine

If the patient is between twenty five and forty,—

(1) Test the distant vision, the manifest hypermetropia, and the near vision,

(2) Test the pupil reactions and the range of accommodation,

(3) Thoroughly examine the eyes with oblique illumination and by the ophthalmoscope.

If it is concluded that the defect is simply due to error of refraction, the further procedure depends upon the results of the subjective testing —

(1) If the vision is 6/6 and J 1, with a low degree of manifest hypermetropia and few asthenopic symptoms glasses may be ordered according to the amount of manifest hypermetropia (*vide* p 528)

(2) If the vision is less than 6/6 no Hm, but J 1 is read fluently when the type is held closer to the eyes than normal, the patient has probably simple myopia   In general homatropine should be instilled, and the glasses ordered according to the retinoscopy and subjective tests under the mydriatic   The expert may feel justified in ordering glasses without using a mydriatic, judging by the subjective tests and his ophthalmoscopic examination, confirmed by retinoscopy without a mydriatic

(3) If the vision is less than 6/6, and 6/6 cannot be read with any spherical glass, or if some letters only of 6/6 can be read—letters with oblique lines, *e g*, Z, being missed in that line and even in the other lines—the patient is probably astigmatic

Homatropine must be instilled, and the refraction corrected by retinoscopy

If the patient is over forty the examination will be exactly as for one between twenty five and forty, except that presbyopia must be taken into account, and greater care must be exercised in instilling a mydriatic Presbyopia affects the distant vision in hypermetropes in such a manner that although 6/6 may not be read with the unaided eye, it may be possible with a convex lens Its effect upon near vision is discussed elsewhere It is of little use to test the near vision of a presbyope without the glass which is necessary to correct the presbyopia, since no useful knowledge is obtained If the vision cannot be improved up to 6/6 with a spherical lens, the patient is probably astigmatic, or has some disease of the eye, e g, incipient cataract If ophthalmoscopic examination indicates merely the presence of astigmatism, homatropine (*never atropine*) should be instilled, but *in every case in which this is done one drop of eserine, 0 5 per cent , is instilled into the eye before the patient leaves* After estimating the error of refraction by retinoscopy it is advisable to see the patient again after the effects of homatropine have passed off before ordering glasses for near vision

Spectacles In children spectacles with large round or "round oval" 'eyes" should be ordered, otherwise the child may look over them

In adults with astigmatism spectacles or rigid pince-nez must be ordered never 'folders" The latter are never to be recommended and are absolutely contraindicated in astigmatism

It is very important that all glasses fit accurately In distant glasses the lenses must be centred so that the optical centres are exactly opposite the centres of the pupils when the visual axes are parallel Near glasses are decentred slightly inwards, and the lenses are tilted so that the surfaces form an angle of 15° with the plane of the face they are then approximately at right angles to the visual axes when the eyes are directed downwards in reading

Various forms of bifocal glasses are sometimes used In them the upper part contains the distant correction the lower part the near If recommended, patients should be warned that they may experience some difficulty in going downstairs and so on, since objects on the ground will appear blurred when looking through the glasses and prismatic effects cause apparent displacement of objects

If tinted glasses are desirable, *e.g.*, in high myopia, albinism, &c., the correcting lenses may be tinted. For use in tropical countries Crookes's glass (*vide* p. 148) may be used.

In cases of irregular corneal astigmatism and high myopia great improvement of vision occurs when a suitably curved glass meniscus is placed in actual apposition to the cornea. Such " contact " glasses can only be borne in few cases and much perseverance is required in their application and removal. They are not free from danger of causing ulceration, &c.

Anomalies of Accommodation

Presbyopia has been already explained (*vide* p 55) It is a physiological condition and therefore not properly included amongst anomalies of accommodation. It is convenient, how ever, to discuss its clinical treatment here, since it is so nearly allied to the correction of errors of refraction

It has been shown that no convex lens of greater strength than 4 D should be ordered to correct presbyopia in the absence of hypermetropia, further, that the rule that a presbyope requires $+ 1$ D for every five years after forty errs on the side of being a somewhat liberal allowance Rather less, and never more, should be ordered Some people, especially if they have hypermetropia, and therefore still stronger glasses for near work, have discomfort with their proper presbyopic correction It is usually due to the absence of any stimulus, derived from the accommodative effort, to converge (*vide* p 546) Theo retically the visual axes should be parallel when the presbyopic correction is used Convergence, however, is necessary in order that both eyes may see the near object It may be eliminated by combining prisms, bases in, with the correcting glasses

In many occupations, *e g*, bootmaking, carpentering and so on, the work is held at a greater distance than ordinary reading distance The correction for work must then be ordered according to the distance, a weaker glass being required for a distance greater than 22 cm

Myopes of course may require no glass for near work Their presbyopic correction is estimated by the algebraic sum of their myopia and presbyopia

Paralysis of Accommodation, or *cycloplegia*, occurs in disease as well as from the direct action of drugs (cycloplegics) such as atropine and homatropine Unilateral cycloplegia is gene rally due to drugs (often through rubbing the eyes after using a belladonna liniment), contusion (*vide* p 436) or to paralysis of the third nerve Bilateral paresis, less commonly paralysis, is most frequent after diphtheria, but may occur after debilitating

illness, influenza, syphilis, diabetes, tabes, cerebral disease, &c
Paresis of accommodation occurs as a premonitory symptom
of glaucoma

In complete paralysis the sphincter pupillæ is also generally
paralysed, so that the pupil is widely dilated   In paresis the
pupil may be scarcely at all affected, especially after diphtheria,
but in this disease the reverse of the Argyll Robertson pupil
may be met with, viz, loss of reaction to accommodation
with retained reaction to light   The symptoms depend upon
the condition of the refraction   If the patient is myopic,
the defect may pass quite unnoticed , if he is emmetropic,
near vision will be alone affected , if he is hypermetropic, both
distant and near vision will be affected, but particularly the
latter   In paresis it may be possible to diagnose the condition
only by carefully measuring the range of accommodation

In diphtheritic cases the paralysis of accommodation follows
the primary attack at an interval of several weeks, and is often
associated with paralysis of the palate, loss of knee jerks, &c
The sore throat may have been very slight and its diphtheritic
character unrecognised   The lesion is probably nuclear,
either toxic or hæmorrhagic   Cycloplegia in middle life
should arouse suspicion of diabetes   It also occurs in chronic
alcoholism

Paralysis of accommodation in children is liable to be over
looked owing to instillation of atropine for estimating errors of
refraction without previously testing the near vision

The prognosis is good in cases due to drugs or diphtheria
In traumatic cases the condition may be permanent

Treatment is that of the cause   Post-diphtheritic cases
should be treated with tonics, especially strychnine   When
ever the condition is bilateral near work can be carried on by
using suitable convex glasses as in the correction of pres
byopia   As a rule, however, the eyes should be kept at rest,
so that it is inadvisable to order glasses   Miotics are some
times used, but they may do harm and seldom do good   The
constant current may be tried

Spasm of Accommodation   It has already been mentioned
that the ciliary muscle has physiological tone which is
abrogated by atropine, and is equivalent to about one dioptre
In some cases it is found that atropine produces a much greater
effect   This can only be due to spasm of the ciliary muscle
It is found only in young patients, and, contrary to what
might be expected more often in myopes than in hyperme
tropes   In any case an actual or relative myopia is produced

Spasm of accommodation is produced artificially by the instillation of miotics

In spontaneous spasm of accommodation there is nearly always some error of refraction. The eyes have usually been subjected to too much near work under unfavourable circumstances   The condition should not be diagnosed unless proved to be present by the use of atropine

Treatment consists in the use of atropine for several weeks The amount of near work must be limited and carried out under good conditions, the error of refraction being carefully corrected

SECTION V

DISORDERS OF MOTILITY OF THE EYE

CHAPTER XXVI

Anatomy and Physiology of the Extrinsic Ocular Muscles

THE internal rectus is inserted into the sclerotic about 5 5 mm to the nasal side of the corneo sceral margin, the inferior rectus 6 5 mm below, the external rectus 7 mm to the temporal side, and the superior rectus 7 5 mm above (Fig 291)
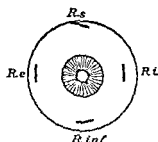
FIG 291 —Lines of insertion of the recti muscles of right eye seen from in front
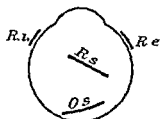
FIG 292 —Lines of insertion of the superior oblique muscle and of the superior, external and internal recti of right eye seen from above

The tendons are about 10 mm broad The origin of these muscles around the optic foramen is much to the nasal side of the posterior pole of the eye It has been proved that when the extrinsic muscles act they turn the eye around a spot which is called the centre of rotation (Fig 293) This spot is situated about 13 5 mm behind the centre of the cornea It lies in the same horizontal plane as the lateral recti Con

sequently when the internal or external rectus acts it rotates the eye horizontally inwards or outwards respectively around a vertical axis through the centre of rotation without any rotation about the horizontal axis. When, however, the superior rectus acts, it not only pulls the eye upwards but also inwards while there is some rotation of the cornea, so that the vertical meridian assumes a direction from above down and out

Fig 293 —Diagram of the lines of action of the extrinsic muscles of left eye (After Fick) C centre of rotation. The arrows show the directions of action of the muscles *I.e* external rectus *P i* internal rectus *R.s* & *inf* superior and inferior recti *O.s* superior oblique *O.i* inferior oblique

(torsion) Similarly when the inferior rectus acts the eye is pulled down and in the vertical meridian of the cornea being deviated so that it lies from above down and in (Fig 294)

The oblique muscles are inserted into the sclerotic behind the level of the centre of rotation (Fig 293) Their direction of action is from behind forwards and inwards Hence the superior oblique pulls the eye downwards and outwards, the inferior oblique upwards and outwards The mechanism is so arranged that when the superior rectus and inferior oblique act simultaneously the eye moves directly upwards i e, the upward movement caused by each muscle is summated while the inward movement and corneal rotation of the superior rectus are exactly compensated by the outward movement and contrary corneal torsion of the inferior oblique Similarly when the inferior rectus and superior oblique act simultaneously the eye moves directly downwards

Every movement of the eyeball is a synkinesis (*vide* p 562) In adversion not only does the internal rectus act but also the superior and inferior recti and it has been shown that the antagonistic muscles are not merely relaxed, but are actively inhibited In abversion the external rectus and both obliques are in action In elevation the superior rectus acts consonantly with the inferior oblique In depression the inferior rectus acts with the superior oblique The movements already described are all around three primary axes—vertical (move

ments in and out), coronal (movements up and down) and sagittal (torsion)—which pass through the centre of rotation Still more complicated are the movements about secondary axes i e, axes passing through the centre of rotation in some other direction such as movements up and in up and out down and in down and out,

Not only is there uniocular synkinesis under normal circumstances there is always also binocular synkinesis Adversion of one eye is accompanied by abversion of the other eye—conjugate deviation elevation or depression of one eye is always accompanied by elevation or depression respectively of the other eye The only exception to this rule is the bilateral
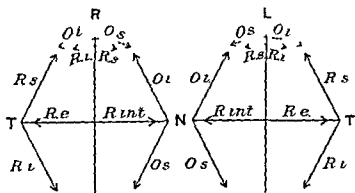
Fig 294—Diagram of the lines of action of the extrinsic muscles upon the cornea (Fuchs) R r ght eye L left eye, T temporal s des N nasal s des The dotted lines show the torsional effects

adversion of the eyes in convergence Elevation of both eyes is accompanied by slight abversion (divergence) depression by slight adversion (convergence)

The oculomotor or third cranial nerve, supplies all the extrinsic muscles except the external rectus and superior oblique , it also supplies the sphincter iridis and ciliary muscle The superior oblique is supplied by the fourth nerve, and the external rectus by the sixth nerve A thorough knowledge of the arrangement of the nuclei of the cranial nerves in the mid brain and medulla, and of the course and relations of the nerves to their destinations, is requisite for accurate diagnosis of the seat of the lesion in cases in which they are involved

The third and fourth nuclei form a large continuous mass of

nerve cells situated near the middle line in the floor of the aqueduct of Sylvius beneath the corpora quadrigemina or colliculi (Figs 295—297) The cells nearest the middle line towards the anterior part of the third nucleus are smaller than the others, they, with the cells of the opposite side form an unpaired nucleus with two divergent horn like processes in front (the Edinger Westphal nucleus) (Fig 29J) which probably supplies fibres to the ciliary muscle (accommodation) and

Fig 295—Diagram of the positions of the nuclei of the third fourth and sixth nerves seen from above *S.c.q* superior corpus quadrigeminum *I.c.q.* inferior corpus quadrigeminum

sphincter iridis (constriction of the pupil) It is probable that in the great large-celled lateral nucleus the levator palpebræ is represented most anteriorly, then from before backwards elevation of the eye, adversion and depression while aversion is relegated to the sixth nucleus, much farther back in the medulla (Fig 299) There is little decussation of the fibres from the third nuclei of the two sides in the anterior part but a considerable amount in the posterior part

The fourth nerve is unique among motor nerves in having a dorsal decussation Nearly if not quite all the fibres decussate in the superior medullary velum and are distributed to the superior oblique muscle of the opposite side

The sixth nucleus is in the immediate vicinity of the facial (seventh) nucleus (Figs 295 298) the fibres from which make a large bend around it (Fig 300) Hence vascular and other lesions of the sixth nucleus are very liable to be accompanied by facial paralysis on the same side All the fibres of the sixth nerve are distributed to the external rectus of the same side

The peculiarities of distribution of the fibres from the third

fourth and sixth nuclei to muscles partly on one side and partly on the opposite side of the body show that the nervous mechanism of co ordina tion of these muscles is extremely complex

A large and important tract of nerve fibres, derived in part from the anterior columns of the spinal cord, lies below and close to the third fourth and sixth nuclei This is the posterior longitudinal bundle (Figs 296—298, 301) Fibres pass between it and the nuclei under consideration, they pro bably have important functions in the co ordination of move ments and equilibration, which are so intimately related with vision Among these fibres are also some which link up the sixth nucleus of one side with the third nucleus of the other in some such manner as depicted in Fig 301, though the exact course of the fibres has not been definitely proved These fibres are con cerned in conjugate de viation of the eyes to one or other side Hence when one sixth nucleus is destroyed the patient

Fig 296 —Diagram of transverse section of the mesencephalon at the level of the third nucleus (level of 1 Fig 301) *Supr c q* superior corpus quadrigemi num *R,* red nucleus *I g b* internal geniculate body *E g b* external geni culate body *O Tr* optic tract
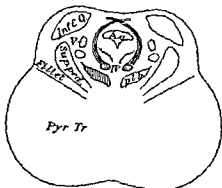
Fig 297 —Diagram of transverse section of the mesencephalon at the level of the fourth nuclei (level of 2 Fig 301) *Aq,* aqueduct of Sylvius *Inf c q* in ferior corpus quadr gem num *p l b ,* pos terior longitud nal bundle *Sup ped* superior peduncle of the cerebellum *Pyr Tr ,* pyramidal tract.

is unable to turn his eyes to the same side, though the power of convergence is unimpaired Nuclear sixth nerve paralysis therefore causes loss of conjugate deviation of the eyes to the same side, and is very likely to be associated with facial

paralysis on the same side, whereas peripheral sixth nerve paralysis causes only loss of power of movement of the same eye to the same side.

The student should revise his knowledge of the anatomical relations of these and the neighbouring cranial nerves in their course from the nuclei to their respective terminations.

Fig 298 —Diagram of transverse section of the pons at the level of the sixth nucleus (level of 3, Fig 301) *p l b*, posterior longitudinal bundle, *D*, Deiter's nucleus, *s o*, superior olive, *C r*, restiform body, *Pyr Tr*, pyramidal tract.

Orientation. Orientation of objects in space depends upon their relation to the nodal point of the eye, i.e., the position of an object is determined by the line passing through the object and the nodal point, the spot where this line cuts the retina being the position of the retinal image of the object. Conversely an object is said to be projected along the line joining the retinal image

Fig 299 —Diagram of the probable position of the nuclei of origin of the fibres to the ocular muscles in the third, fourth and sixth nuclei

with the nodal point Objective orientation determines the relative positions of objects to each other. Subjective orientation, or the exact relation of the situations of objects

ourselves, is much more complex, depending upon an
ccurate knowledge of the position of the body and of
he eyes in the body, derived largely from the muscular
ense

Corresponding Points When a distant object is looked at
he visual axes are practically parallel the object forms an
mage upon each fovea centralis An object to one side of the
bject looked at forms its retinal images upon the temporal side
f one retina and upon the nasal side of the other, these are
alled corresponding points Points on the two retinæ which
re not corresponding points in this sense of the term are called
sparate points If an object forms
s retinal images upon disparate
ints it will be seen double (binocular
plopia) If the disparity is slight
ere is a great tendency to move the
es so that the images may be fused
will be noticed that the two fovea
re corresponding points

When a near object is looked at the
es converge the requisite amount to
ng the two retinal images of the
bject upon the two yellow spots

Binocular Vision When the eyes
re normal the individual sees clearly
h both eyes the object looked at
he retinal images of the two eyes
re not, however, identical This is
bvious when it is remembered that
ere is a considerable distance be-
ween the two eyes If the object is
solid body, e g , a cube, the right
ye sees a little more of the right side
f the object, and *vice versâ* The two images are fused psycho
gically, and it is this fusion of the slightly diverse images,
ombined with other facts derived from experience, which
nables the person to appreciate the solidity of objects The
stimation of the relative distance of objects in or near the line
f vision is still more complex It probably depends upon the
act that the images of objects farther or nearer than the object
xed are situated at disparate points on the retinæ A more
stant object will produce heteronymous diplopia, a nearer
omonymous diplopia, as can be shown by experiment The
plopia is suppressed in actual vision, but it produces a
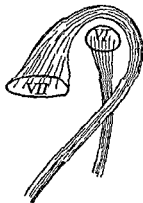
Fig 300 —Diagram of the
sixth nucleus and its
relation to the nucleus
and the emerging fibres
of the seventh nerve
The relations cannot be
accurately depicted in
one plane

psychological impression which is translated into appreciation of distance It will suffice if it is well understood that accuracy of stereoscopic and topical vision depends upon good sight with both eyes simultaneously

Convergence and Accommodation When a distant object is observed by an emmetropic person the visual axes are parallel and no effort of accommodation is made If a near object is observed the eyes converge upon it and an effort of accommodation corresponding with the distance of the object is made Convergence can be tested roughly by making the patient fix

a finger or pencil which is gradually brought nearer to the eyes in the middle line The eyes should be able to maintain convergence when the object is 8 cm (3¼ inches) from the eyes If outward deviation of one eye occurs before this point is reached the power of convergence is deficient There are various methods of recording the amount of convergence One very convenient method employs the *metre angle* as a unit Suppose an object to be situated in the median line between the two eyes at a distance of one metre Then the angle which the line joining the object with the centre of rotation of either eye makes with the median line is called one metre angle (Fig 302) With an interpupillary distance of 60 mm this angle is about 2° If the object is two metres away the angle is approximately half as great, or ½ m a If the object is 50 cm away the angle will be 2 m a Now, the amount of accommodation which an emmetropic eye exercises in order to see clearly an object 1 m away is 1 D, 2 m away 0 5 D 50 cm away 2 D &c Hence with an emmetropic person the amount of convergence reckoned in metre angles is the same as the amount of accommodation reckoned in dioptres

The amount of convergence can also be measured by prisms

Fig 301 —Diagram of the course of the fibres from the sixth nucleus which are concerned in conjugate deviation of the eyes 1 ° 3 l nes of section of F gs 296—298

If an object one metre distant is looked at through a prism with the base directed outwards placed before one eye, *e g*, the right, it may still be seen as a single object (Fig 303) Now in order that the object may form its image upon the fovea of this eye it is necessary that the eye should be turned inwards an amount corresponding with the angle of deviation of the prism (*vide* p 28) This method, besides affording a method of recording amounts of convergence, also shows that the relationship between convergence and accommodation is somewhat elastic In the experiment described, although the amount of accommodation exercised remains the same, the amount of convergence is altered Indeed, if the relationship were quite unalterable a hypermetropic person would invariably have diplopia, for his accommodation is always in excess of the corresponding value of the amount of convergence exerted by an emmetrope Moreover, the power to converge would gradually be lost *pari passu* with loss of accommodation in advancing age

If in the experiment described above the prism is held before the right eye with its base inwards it will still be found possible to see the object single (Fig 304) Further, a distant object is still seen single under the same conditions if the prism has only a small angle of deviation This can only be accomplished by active divergence of the eyes to an amount corresponding with the angle of deviation of the prism The power of divergence, which may therefore be considered to be negative convergence, is much less than the power of convergence Just as the difference in the amount of accommodation between the far point and the near point is called the *amplitude of accommodation* so the difference in convergence between the far point and the near point is called the *amplitude of convergence* Whereas, however, negative accommodation, *i e*, ability to see a point beyond infinity, or in less mathematical terms, so to flatten the lens that a myope could see clearly without glasses, is impossible, negative convergence, as has been seen, is possible
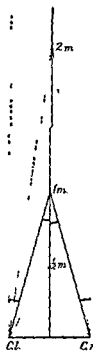
Fig 302—Diagram of the metre angle *Cr*, *Cl* centres of rotation of the right and left eyes

within small limits The amplitude of convergence therefore
consists of a negative portion and a positive portion. The
former is measured by the strongest prism, base inwards,
which can be borne without producing diplopia in distant
vision. The latter is measured by the strongest prism, base
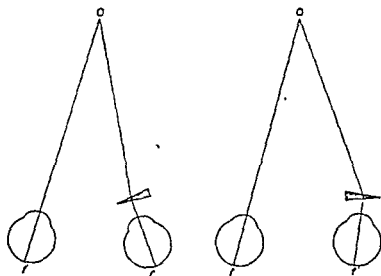
FIGS 303-304 —Diagrams of the action of adducting and abducting
prisms. O, object of fixation , f, f', left and right fovea centrales

outwards, which can be borne without producing diplopia in
the nearest possible vision

The convergence synkinesis is so co-ordinated that the
energy exerted is accurately divided between the two internal
recti Hence it is found that the effect is the same in the
above experiments whether the prism is placed before only one
eye, or a prism of half the strength is placed before each eye.

Paralytic and Kinetic Strabismus   Synkineses
Nystagmus

Strabismus (στρεφειν, to turn) or squint is a generic term
applied to all those conditions in which the visual axes assume
a position relative to each other different from that required by
the physiological conditions   Strabismus may be provisionally
divided into two great groups   (1) those due to known cause;
(2) those due to unknown cause   To the first group belong
(a) those due to paresis or paralysis of one or more of the
extrinsic muscles—*paralytic strabismus*, (b) those due to
irregular activity or over activity of individual muscles or
groups of muscles—a sub group which I propose to designate
kinetic strabismus   To the second group belong (a) those
cases which are characterised by the fact that the visual axes,
though abnormally directed, retain their relative position in
all movements of the eyes, they are therefore termed *con-
comitant* or *comitant strabismus*   Another sub group of the
second class is (b) cases in which there is *latent strabismus* or
heterophoria

PARALYTIC STRABISMUS

Signs and Symptoms   (1) *Limitation of Movement*   In
paralysis of an ocular muscle the ability to turn the eye in
the direction of the normal action of the muscle is diminished
or lost   In slight paresis the defect in mobility may be so
small as to escape observation without special tests   In all
positions in which the affected muscle is not brought actively
into play the visual axes assume their normal relationship

Limitation of movement is tested roughly by fixing the
patient s head and telling him to follow the movements of the
surgeon's finger   The finger should be held vertical in testing
horizontal movements, horizontal in testing vertical move-
ments   An accurate record of the movements of each eye can
be obtained by taking the field of fixation   The patient is
seated at the perimeter as for recording the field of vision.
With the head fixed and the other eye screened the patient

549

looks as far as possible along the arc of the perimeter, test types being moved in from the periphery until he is just able to read them. The normal field of fixation is about 50° downwards and 45° in all other directions

When the eyes are turned in the direction of the normal action of the paralysed muscle the affected eye remains stationary   It deviates therefore relatively to the other eye, this position is called the *primary deviation* (Fig 305)
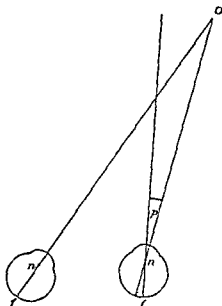
Fig 305 —Diagram of primary deviation in paresis of the right external rectus   *p* angle of primary deviation, *n, n*, left and right nodal points

The angle of deviation is the angle which the line joining the object observed with the nodal point makes with the visual line

If the sound eye is covered by a screen, and an attempt is made to fix an object so situated that the paralysed muscle is brought into play, it will be found that the eye behind the screen deviates more than the primary deviation of the paralysed eye   For example, if the right external rectus is paralysed and the left eye is covered   then on attempting to fix an object situated to the right with the right eye the left eye will deviate very much to the right, so much in fact that

its line of vision is well to the right of the object fixed Hence, if the screen is removed suddenly the left eye will spring back to the left so as to take up fixation This deviation of the sound eye is called the *secondary deviation* (Fig 306) The reason why the secondary deviation is greater than the primary is that in conjugate deviation of the eyes the nervous energy is equally distributed between the muscles of the two
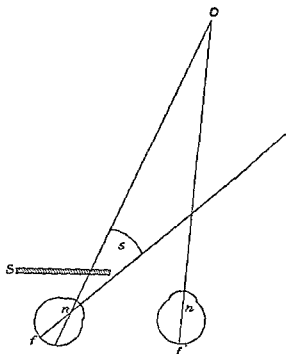
Fig 306—Diagram of secondary deviation in paresis of the right external rectus S screen in front of left eye *s*, angle of secondary deviation

eyes Now the effort to take up fixation with the paralysed or paresed eye is much greater than normal Consequently the sound eye behind the screen moves through a greater distance than normal, *i e*, through a distance corresponding with the excessive effort exerted This feature is of great importance because when well marked it distinguishes paralytic squint from the concomitant type in which the secondary deviation is equal to the primary

(2) *Diplopia* The chief complaint of patients with paralysis of an extrinsic muscle is often that they see double Diplopia

occurs only over that part of the field of fixation towards which the affected muscle or muscles move the eye   If both eyes are functional and one deviates, *i e*, if the visual axes are not parallel in looking at a distant object, or if the amount of convergence is not accurately adapted to the position of the object in near vision *binocular diplopia* results   When the deviation is due to paralysis of one or more extrinsic muscles, the eye on the sound side fixes the object accurately, while the other eye deviates   Suppose the left eye fixes accurately

while the right deviates inwards, a bright, sharply defined foveal image is seen with the left eye   The image formed by the object on the right retina falling as it does upon the line joining the nodal point with the object, lies to the nasal side of the retina   The patient being unconscious of the malposition of his eye orients the object subjectively as if the eye were straight   He knows from experience that objects which form their images upon the nasal side of the retina are situated to the temporal side   He therefore projects the object with this eye to the right   This is called *homonymous diplopia*, because the object as seen by the right eye is to the right of the object as seen by the left eye (Fig 307)

If the right eye deviates outwards, *heteronymous* or *crossed diplopia* results because the object as seen with the left eye lies apparently to the right of the object as seen by the right eye (Fig 308)

Fig 307 —Diagram of homonymous diplopia *f f* left and right foveæ *n n* left and right nodal points   The image of O formed at *a* is projected as if *a* were the fovea *i e* to O

In binocular diplopia the image seen by the squinting eye (false or apparent image) is less distinct than that seen by the fixing eye (true image), because only in the latter case does the image fall upon the fovea centralis   The angular displacement of the false image is equal to the angle of deviation of the eye

(3) *False Orientation*   It will be seen from what has

already been said that false orientation is a necessary accompaniment of binocular diplopia. Suppose that a patient whose right external rectus is paralysed shuts his left eye and attempts to fix an object situated towards the right. Let him now quickly strike at the object with his extended index finger. The finger will pass considerably to the right of the object. This is called *false projection*. It depends upon exactly the same principle as the increase of the secondary deviation. The object is projected according to the amount of nervous energy exerted, as this is greater than that exerted under normal circumstances, the object is projected too far in the direction of action of the paralysed muscle. It is essential that the finger should be directed at the object quickly, otherwise the error is noticed and compensated for. For example, if under the same circumstances the patient is told to walk towards an object situated at some distance to the right, he first steps too far to the right, then recognises his mistake and corrects it. In old paralysis the patient may learn by experience completely to compensate for the deficiency.

(4) *Position of the Head.* The patient holds his head so that his face is turned in the direction of action of the paralysed muscle. For example, in paralysis of the right external rectus the patient keeps his head turned to the right. The object of this manœuvre is to abolish the diplopia and its attendant unpleasant consequences as much as possible. In complex paralysis the position of the head is still such as to relieve the diplopia to the maximum extent, the position being adopted unconsciously.

Fig 308.—Diagram of heteronymous (crossed) diplopia

"*Ocular torticollis*" is a term sometimes applied to tilting of the head to compensate defective vertical movements of one eye. It is distinguished from true torticollis in that there is a simple tilting of the head, the chin not being rotate l towards the opposite shoulder, moreover, the sterno mastoid is not unduly contracted

It occurs chiefly in cases of congenital origin—probably mal insertion of the muscles—but has been met with after interference with the pulley of the superior oblique in frontal sinus operations The vertical defect is made manifest by placing the head straight, when diplopia is also elicited   Partial myomectomy of the inferior oblique on the side opposite to the direction of the head tilt corrects the deformity in some cases

(5) *Vertigo, &c*   Vertigo, leading to nausea, and even vomiting, is due partly to diplopia, partly to false projection It occurs chiefly when the paralysed muscle is called upon to exert itself   When the gaze is turned from the region of correct to that of false localisation, objects appear to move with increasing velocity in the direction in which the eye is moving   The unpleasant symptoms are counteracted par tially by altering the position of the head, or completely by shutting or covering the affected eye

In paralyses of long standing, false orientation gradually ceases (*vide supra*) Diplopia also tends to disappear or become less troublesome, the patient learns to ignore the impres sions derived from the affected eye   Contracture of the antagonists of the paralysed muscle gradually sets in, which has the effect of increasing the primary deviation   Since the retinal image is thus thrown farther to the periphery, where the sensitiveness is less (*vide* p 66), its suppression is facilitated

Investigation of a Case of Ocular Paralysis   The patient usually seeks advice on account of diplopia   In some cases the nature of the case is obvious immediately from the stra bismus or from the manner in which the head is held   In most cases these features are too slight to decide the diagnosis

(1) The first procedure should be to cover one eye in order to determine whether the diplopia is uniocular or binocular

(2) Having decided that the diplopia is binocular the patient should fix the surgeon's finger, and the field of fixation of each eye should be carefully investigated (*vide* p 567) In cases of complete paralysis of one or more muscles it may be possible to make an accurate diagnosis from the observa tion of the defective movements combined with investigation of the exact positions of the images of the finger in different areas of the field of binocular fixation   In cases of paresis the differentiation of the images is too obscure to permit of the solution of the problem by this means

(3) In such cases the diplopia must be investigated by more

delicate tests The patient is taken into a dark room A red glass is placed before one eye in order to distinguish its image A lighted candle or preferably a bar of light through a stenopœic slit in a hand torch is then moved about in the field of binocular fixation at a distance of at least four feet from the patient, the patient's head being kept stationary The positions of the images are accurately recorded upon a chart with nine squares marked upon it (Fig 309) The examination may be carried out by the surgeon turning the patient's head in various directions while the candle is kept stationary. The following data are derived from this examination —

(a) The areas of single vision and diplopia ,

(b) The distance between the two images in the areas of diplopia ,

(c) Whether the images are on the same level or not ,

(d) Whether one image is inclined or both are erect ,

(e) Whether the diplopia is homonymous or crossed

These data, if concordant, *are sufficient to diagnose the paralysis*. The false image is determined by the direction in which the images are most separated from each other This is the direction of the normal action of the paralysed muscle The false image can often be recognised by being the fainter of the two or by being tilted , by covering one eye it can be shown to which eye this image belongs

Fig 309 —Diplopia chart for the right external rectus The oblique line through the chart shows the limit of the fields of single vision and of diplopia The dotted arrows show the positions of the false image in different parts of the field of diplopia

It must be remembered that these tests are purely subjective In many cases the patients are stupid or their intelligence is obscured by intracranial disease , or contracture of the antagonistic muscles may have set in Consequently the answers are not infrequently discordant, and accurate diagnosis may be extremely difficult or impossible There are two not infrequent causes of ambiguity The paresis may unmask a latent squint (*vide* p 587), or the patient may fix with the paralysed eye, especially if this eye has the greater acuity of vision

It occurs chiefly in cases of congenital origin—probably mal insertion of the muscles—but has been met with after interference with the pulley of the superior oblique in frontal sinus operations The vertical defect is made manifest by placing the head straight, when diplopia is also elicited   Partial myomectomy of the inferior oblique on the side opposite to the direction of the head tilt corrects the deformity in some cases

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(*b*) The distance between the two images in the areas of
diplopia,

(*c*) Whether the images are on the same level or not,

(*d*) Whether one image is in
clined or both are erect ,

(*e*) Whether the diplopia is
homonymous or crossed

These data, if concordant,
are sufficient to diagnose the
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This is the direction of the
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Fig 309 —Diplopia chart for the
right external rectus The oblique
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There are two not infrequent causes of ambiguity The
paresis may unmask a latent squint (*vide* p 587), or the
patient may fix with the paralyzed eye, especially if this eye
has the greater acuity of vision

The nature of the diplopia and the position of the images in each of the nine areas of the field of fixation for paralysis of each individual muscle should be worked out by the student. In performing this exercise he should rely upon his knowledge of the anatomy of the muscles and their consequent action in each position of the eye. Considerable ingenuity has been used to devise mnemonics for determining the position
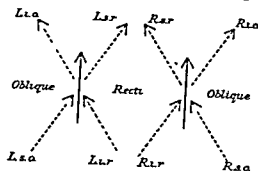
Fig 310—Werner's mnemonic for paralyses of elevator and depressor muscles. Note that the right muscles are to the right, the left to the left: recti in centre, obliques outside, superior recti above, superior obliques below. The diagram illustrates the normal actions of the muscles and the type of diplopia caused. For example:—the recti adduct the obliques abduct, the superior muscles (R.s.r, L.s.r. R.s.o., L.s.o.) produce inward torsion, the inferior muscles out ward torsion, the movement follows the direction of the arrow, eg R.s.r moves the eye inwards and upwards and causes inward torsion. *Diplopia* The false image (broken arrows) is displaced in the direction of action of the muscle, therefore, for muscles in the upper half (L.s.o, L.s.r. R.s.r, R.s.o.) the diplopia occurs on upward movement of the eyes, and the false image is higher than the true The diagram also shows whether the diplopia is homonymous or crossed If the patient fixes with the paralysed eye the figure must be rotated so that the false image becomes vertical

of the false image One of the most satisfactory is shown in the accompanying diagram (Fig 310) It may be pointed out that all the signs, with the exception of the deviation of the eye, viz, defective movement, false projection, increase of diplopia, secondary deviation, and position of the head, are towards the side of the paralysed muscle

Varieties of Ocular Paralysis If one muscle alone is affected it is generally the external rectus or the superior oblique, since each of these is supplied by an independent nerve

Affection of several muscles simultaneously is usually due to paralysis of the third nerve All the extrinsic and intrinsic muscles of one or both eyes may be paralysed—*ophthalmoplegia*

totalis (vide p 599)   If only the extrinsic muscles are affected
the condition is called *ophthalmoplegia externa* , if only the
intrinsic (sphincter pupillae and ciliary muscle) *ophthalmoplegia
interna*

Conjugate paralysis is the term applied to abolition of certain
synkineses   Thus ability to look up to the right or left, or
down may be lost   Inability to converge may also occur
Such defects might be conveniently termed *symparalyses*

Paralysis of the External Rectus   There is limitation of
movement outwards, and the face is turned towards the
paralysed side   Diplopia occurs on looking to the paralysed
side   It is homonymous , the images are on the same level,
and erect, becoming more separated on looking more towards
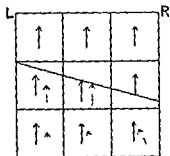
Fig 311 -Diplopia chart for the
right superior oblique
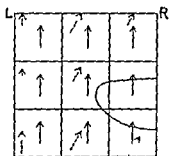
Fig 312 -Diplopia chart for the
right third nerve   The area
enclosed by the curved line is
the area of single vision

the paralysed side   The false image is slightly tilted on looking
up or down as well as towards the paralysed side (Fig 309)

Paralysis of the Superior Oblique   There is limitation of
movement downwards and towards the paralysed side , the
face is turned downwards and towards the sound side   Dip
lopia occurs on looking down (Fig 311)   It is homonymous,
the false image is lower and its upper end is tilted to the
true image   The distance between the images and the inclina
tion of the false image increase on looking down and towards
the paralysed side   The patient has great difficulty in going
downstairs, and vertigo is usually a particularly prominent
symptom

Paralysis of the Third Nerve   In complete paralysis of the
third nerve there is ptosis, which prevents diplopia   On
raising the lid with the finger the eye is seen to be deflected
outwards and somewhat downwards, owing to the tone of the

two unparalysed muscles   The pupil is semi-dilated and immobile, and accommodation is paralysed   There is a slight degree of proptosis, owing to loss of tone of the paralysed muscles   There is limitation of movement upwards and inwards, to a less degree downwards   With the lid raised there is diplopia, which is crossed, the false image being higher, with its upper end tilted towards the paralysed side (Fig 312),
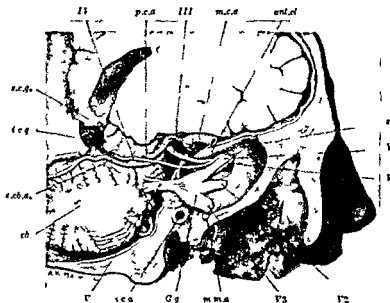
Fig 313—Third Fourth Fifth and Sixth Nerves   *G g* Gasserian ganglion   *i c a* internal carotid artery   *m m a* middle meningeal artery   *p c a* posterior cerebral artery   *m c a* middle cerebral artery   *sup r o f* superior orbital fissure,   *s c q*, superior corpus quadrigeminum   *i c q* inferior corpus quadrigeminum   *s cb a*, superior cerebellar artery   *cb* cerebellum   (Eugene Wolff   Anatomy of the Eye and Orbit   Lewis London)

Paralysis of the third nerve is often incomplete, and individual muscles may occasionally be affected alone

Ætiology   Paralysis of ocular muscles may result from a lesion situated in any part of the nerve-tracts from the cerebral cortex to the muscles   The site may therefore be intracranial or intraorbital   Cortical lesions usually cause loss of synergic movements, *e g*, conjugate deviations, but simple ptosis may be due to such a lesion   The diagnosis of nuclear and peripheral lesions depends largely upon knowledge of the

anatomical relations of the nuclei and nerves It is beyond
the scope of this work to treat the subject exhaustively here
It may be mentioned that paralysis of the external rectus,
sometimes bilateral, is common in babies It may be due to
the use of forceps during delivery, the sixth nerve being most
exposed to pressure or to maldevelopment of the nucleus In
the latter case there is loss of conjugate deviation to the same
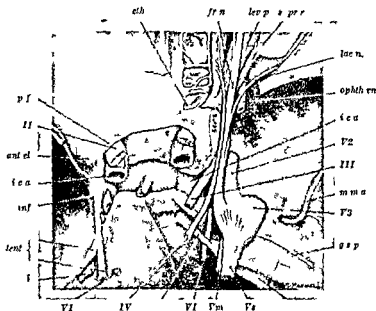
Fɪɢ 314 —Third Fourth Fifth and Sixth Nerves *eth* ethmoidal
cell, *fr n* frontal nerve *lev p* levator palpebræ *supr r* superior
rectus *lac n* lacrymal nerve *ophth vn* ophthalmic vein *i c a*,
internal carotid artery *m m a* middle meningeal artery *g s p*,
great superficial petrosal nerve *tent* tentorium *inf* infundibulum,
ant cl anterior clinoid process *p f* processus falciformis (Eugene
Wolff Anatomy of Eye and Orbit Lewis London)

side (*vide* p 543) and the seventh nerve is normal In
acquired sixth nuclear paralysis in adults the seventh nerve
is usually implicated (*vide* p 543) In congenital paralysis of the
external rectus contracture of the antagonists does not occur
Other nuclei may be maldeveloped, or they may be picked
out by the lesions of syphilis, tabes, disseminated sclerosis, or
poliœncephalitis

The commonest cause of ocular paralyses is syphilis, which
may affect the nerves at their origin or in any part of their

course (see Section VI) Syphilitic paralysis is usually a late
manifestation The third nerve is affected most frequently,
but not necessarily equally in all its branches Tabes is
responsible for a large proportion of the cases (*vide* p 592)

Ocular paralyses of intracranial origin may be due to affec-
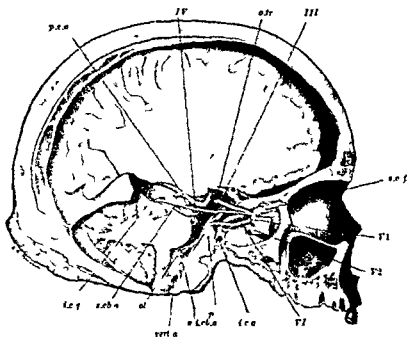
Fig 315—Course of Sixth Nerve *p c a* posterior cerebral artery
o tr optic tract *s o f* superior orbital fissure *i c a* internal
carotid artery *p* petrous portion of temporal bone, *a i c b a*,
anterior inferior cerebellar artery, *vert a* vertebral artery, *ol*,
olive *s c b a* superiorcerebellarartery, *i c q* infer or corpus quadri
gemin m (Eugene Wolff Anatomy of the Eye and Orbit."
Lewis London)

tions of the blood vessels—hæmorrhage, thrombosis, &c—or
to external pressure—tumours bloodclots, periostitis, &c

Other causes are diphtheria, diabetes and other toxic
conditions injury, &c Paralysis of both extrinsic and in-
trinsic ocular muscles is a common and early feature in
encephalitis lethargica Paralysis especially of the external
rectus, sometimes follows spinal anæsthesia with stovain , the
onset is rapid, and recovery usually takes many weeks
Ophthalmoplegic migraine is a rare cause (*vide* p 412)

Paralysis of the external recti is common in cases of intra-cranial tumours with high intracranial pressure, and generally has no localising value. It may be due to traction on the nerves as they bend over the apex of the petrous portion of the temporal bone (Wolff, Figs. 315, 316), or to pressure by the anterior inferior cerebellar and internal auditory arteries, which cross them at right angles and often lie ventral to them (Fig. 330) —the nerves are strangulated between the vessels and the œdematous and swollen pons (Cushing). This may also account for the spinal anæsthetic cases, and for ophthalmoplegic
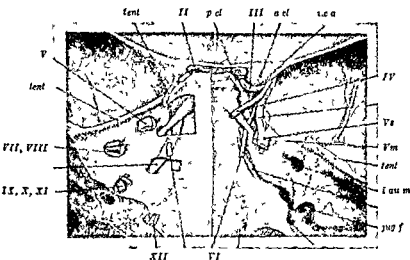
Fig. 316.—Course of Sixth Nerve *tent,* tentorium ; *a cl , p cl,* anterior and posterior clinoid processes ; *i c a,* internal carotid artery ; *i a u m ,* internal auditory meatus ; *jug f ,* jugular foramen. (Eugène Wolff " Anatomy of the Eye and Orbit " Lewis, London)

migraine, the third nerve passing between the superior cerebellar and the posterior cerebral arteries.

Injury to and disease of the orbit may affect the nerves of muscles in this situation by rupture, pressure, inflammation, &c.

The prognosis varies with the cause. Ocular paralyses are so often early signs of grave nervous disease that the prognosis should always be guarded. Those due to peripheral disease, dependent upon syphilis or "rheumatism," may speedily recover. Long-standing cases rarely recover.

Treatment. Syphilitic cases should be treated by mercury and increasing doses of iodides, and this treatment should be applied to all doubtful cases. N.A.B. should be tried in

intractable cases   Some cases improve on salicylates, or colchicum and iodides   Diaphoresis may be used   The constant current is chiefly useful in keeping up the metabolism of the muscles until innervation is re-established   It probably has little therapeutic influence upon the paralysed nerve

Occasionally symptomatic treatment affords relief to the patient   The diplopia may sometimes be relieved by suitable prisms but this treatment is rarely of much use owing to the variation in the amount of the deviation in different positions of the eyes   Occasionally good is done by exercising the weak muscle with strong prisms (*vide* p 590)   In old cases an operation may be indicated usually tenotomy of the antagonist with advancement of the paralysed muscle thus putting the affected muscle under better mechanical conditions   It is only suitable for paretic not paralytic cases and should never be adopted until all other means have failed   It is therefore seldom indicated

If diplopia is very troublesome and cannot be relieved by the means suggested spectacles should be ordered with a ground glass in front of the affected eye

KINETIC STRABISMUS

Aberrant forms of strabismus occur as the result of irritative intracranial lesions and are due not to paralysis but to irregular action or over action of certain muscles caused by unequal stimulation of the nerve centres or nerves   Such squints are common in meningitis and lesions of the mid brain or cerebellum, such as tumours (glioma tubercle gumma &c)   The occurrence of the squint only during epileptiform fits or its irregularity of type may render the diagnosis from paralytic squint easy especially when there are other prominent symptoms of cerebral irritation   In other cases e pecially in the early stages of the disease the diagnosis from paralytic or concomitant squint may be extremely difficult

SYNKINESES

The extrinsic muscles take part in many normal and pathological synkineses   When the eyes look up the levatores palpebrarum raise the lids and in extreme upward movements the frontales also contract   In congenital ptosis (*q v*) upward movement of the eyes is often defective   On looking down the lid follows the globe   In exophthalmic goitre the lid follows tardily or not at all (von Graefe s sign)   in total facial paralysis the lid

follows the globe on looking down, though the eye cannot be closed voluntarily On closing the eyes, as in sleep, the eyes generally turn upwards and outwards The same movement of the eyes occurs on attempted closure in total facial paralysis On the other hand, the eye sometimes closes in total seventh nerve paralysis on synergic activity of other facial muscles, as in laughing The so called "jaw winking" synkinesis is particularly striking In these rare cases one levator palpebræ is thrown into activity during eating, and sometimes on reading aloud The lid movement is usually specially associated with lateral movements of the jaw, due to action of the pterygoid muscles, which are innervated by the fifth nerve In most cases, but not all, there is slight ptosis of the affected lid and in cases with congenital ptosis the synkinesis occurs on sucking Allied to the jaw winking cases are others in which spasmodic lid movements occur on lateral deviation of the eyes The convergence pupillary synkinesis has already been mentioned to it may be added the contraction of the pupil on forced closure of the lids In rare cases spontaneous rhythmical variations in the size of the pupil are accompanied by ocular or lid movements. They are usually associated with con genital or early infantile paresis of the third nerve The pupil contracts rapidly to about 2 mm diameter, then after 5—10 seconds dilates slowly to 6—7 mm , contracting again after 15—20 seconds Contraction is hastened by action of the internal rectus, dilatation by action of the external rectus The move ments are accompanied by spasm and relaxation of the ciliary muscle

Nystagmus

Nystagmus (ινσταζω, to nod) is the term applied to rapid oscillatory movements of the eyes, independent of the normal movements, which are not affected The oscillations are involuntary, though in rare cases normal persons can imitate them They are usually lateral, but vertical, rotatory and mixed rotatory and lateral or vertical nystagmus are not uncommon The condition is almost always bilateral, though the movements may be much more marked in one eye than the other In such cases it may be necessary to examine the eye very carefully with the ophthalmoscope (corneal reflex, retinal vessels, &c) before the presence of nystagmus can be demonstrated Unilateral nystagmus does occur, but it is probable that many of the cases described are really bilateral

Nystagmoid jerks, i e , larger rhythmic jerking movements, most pronounced at the extreme limits of the normal move ments of the eyes, should be distinguished from true nystagmus They are not uncommon in normal people

under certain conditions—fatigue, railway travelling &c The fundamental cause is probably quite different from that of true nystagmus, though both may occur together

Nystagmus may be congenital or early infantile, or it may be acquired These two groups of cases should also be carefully distinguished on account of their different pathological foundation. Congenital and early infantile nystagmus, i e, nystagmus dating from birth or within a few weeks of birth, occurs in congenitally malformed eyes, in albinism and in eyes with congenital or early developed opacities of the media, e g, leucoma or anterior polar cataract due to ophthalmia neonatorum (q v) macular changes, &c The cause in these cases is inability to develop normal fixation Fixation is developed during the first few weeks of life, the eyes being moved aimlessly and independently before it is acquired Any cause seriously diminishing the acuity of macular vision occurring at this period is liable to give rise to nystagmus, if the eye is blind, nystagmus is not developed Nystagmus is present in most cases of total colour blindness (q v) in which vision is carried out by the rods alone, and there is therefore a central scotoma In some congenital cases it is impossible to discover any cause In a few such cases ancestors or relations have been albinos

Nystagmus may be acquired in infancy after the period at which fixation is developed This form occurs in spasmus nutans, in which it is associated with nodding movements of the head It occurs in the first year of life The nodding of the head may be antero-posterior (affirmat on), lateral (negation), or rotatory It develops some weeks before the nystagmus, ceases during sleep, and disappears before the nystagmus The nystagmus is very fine and rapid and may be vertical, rotatory, or lateral It is generally more marked in one eye The whole symptom-complex disappears in time—one of the few cases in which nystagmus disappears spontaneously The nystagmus may disappear in one eye before the other, such cases may be mistaken for true unilateral nystagmus In rare cases head nodding with nystagmus is congenital and hereditary, and in these cases persists throughout life (Hancock)

Nystagmus in adults occurs in disseminated sclerosis disease of the cerebellum and vestibular tracts, and of the semicircular canals (e g, occasionally on syringing the ears) Friedreich's ataxia, &c In disseminated sclerosis the movements are generally horizontal and are elicited in the early stages only in extreme lateral positions of the eyes Cerebellar irritative lesions cause coarse nystagmus towards the side of the lesion

and fine nystagmus to the opposite side   Some of these cases show analogy with hippus (vide p 61), and like it are probably dependent upon the rhythmic activity of nerve centres   Nystagmus may also occur in adults as an " occupation neurosis," the commonest form being coal miners' nystagmus (vide infra)

In congenital and early infantile nystagmus the patient is wholly unconscious of the movements, since objects do not appear to move   Vision is usually defective in spite of correction of errors of refraction which generally accompany the defect   In some cases of acquired nystagmus in adults objects appear to move

The prognosis is good in spasmus nutans and in miners' nystagmus if the occupation is changed, though recovery is slow   In all other cases it is bad, though it tends to diminish with advancing years   Treatment is therefore palliative, consisting in correction of refraction, wearing smoked glasses in albinism, and treating any disease which may be present

Labyrinthine Nystagmus occurs in disease of the internal ear in which the semicircular canals are involved, and can be produced in normal subjects by rotation in a specially designed chair or by passing a galvanic current through the head   The nystagmus is rhythmic, with a rapid and a slow component, is bilateral, and horizontal or rotatory, but varies according to the semicircular canal stimulated   Either pair of semicircular canals can be stimulated by rotation with the head in a suitable position   Destruction of one labyrinth causes rhythmic nystagmus towards the opposite side, which ceases if the other labyrinth is destroyed

Miners' Nystagmus occurs chiefly in those who have worked long at the coal face   The patient complains of defective vision which is worse at night   headache, giddiness, photophobia, dancing of lights and movements of objects   The nystagmus is essentially rotatory and very rapid , in latent cases it is elicited by fixing the head and making the patient look up   In severe cases the lids are nearly closed and the head is held backwards   there is tremor of the head and eyebrows   The disease is six times as common in pits which use safety lamps as compared with those that use naked lights, and varies inversely with the illumination (Llewellyn)   Continual looking upward at work is only a contributory cause, other such causes being ill health, accidents, errors of refraction   subnormal pigmentation &c   Scotopia, or vision in a dull light, is carried out almost entirely by the rods   Under these circumstances visual acuity is greatest $10°—15°$ outside the fovea and there is a physiological central scotoma   There is great difficulty in keeping up fixation and

the evidence is strongly in favour of the view that low illumination is the essential ætiological factor in miners' nystagmus. Improvement in miners' lamps and in the lighting of mines would probably eliminate the disease, which is a cause of enormous economic loss in compensations, &c. There is, however, a large psychoneurotic factor in all cases

Concomitant Strabismus   Heterophoria
Congenital Defects

CONCOMITANT STRABISMUS

IN concomitant strabismus the visual axes, though abnormally directed, retain their abnormal relation to each other in all movements of the eyes   It differs therefore in this respect from paralytic strabismus, in which the relationship of the visual axes to each other changes with every movement of the eyes in the direction of action of the paralysed muscle or in the resultant direction of action of the paralysed muscles when more than one is affected The secondary deviation in concomitant squint is equal to the primary deviation, a fact which demonstrates the absence of paralysis (Figs 317, 318)   The deviation of the visual axes may be convergent or divergent, the former being the more common

In every case in which the direction of the visual axes is aberrant paralytic strabismus must first be eliminated by testing the movements of the eyes in all directions with the finger   If they are found to be normal and there is no complaint of diplopia, it may be concluded that there is no paralysis   It does not follow that there is concomitant squint The convergence or divergence of the axes may be only apparent   A marked appearance of convergent squint is sometimes seen in myopic eyes, of divergent squint in hypermetropic eyes   It will be observed later that true concomitant
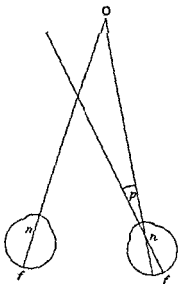
FIG 317—Diagram of primary deviation in concomitant convergent strabismus

convergent squint is most commonly associated with hyper
metropia, divergent with myopia, *i e*, the opposite of apparent
strabismus

Apparent strabismus is due to the fact that the visual axis of
the eye is very rarely coincident with the optic axis (Fig 319)
The optic axis, *i e*, the axis upon which the cornea and lens are
centred, passes through the centre of rotation of the eye and
approximately through the centre of the pupil The visual
axis passes through the nodal point and the fovea centralis,
thus crossing the optic axis
and making a small angle
with it This angle is very
nearly equal to an angle
which is called the angle
gamma, it is commonly
spoken of clinically as the
angle γ In the emmetropic
eye the angle γ is said to
be positive, *i e*, the optic
axis cuts the retina internal
to the fovea centralis In
hypermetropic eyes the angle
γ is also positive but greater
than in emmetropia In
myopia the angle γ is absent
or negative, *i e*, the visual
axis and the optic axis co-
incide or the latter cuts the
retina external to the fovea
centralis

Fig 318 —Diagram of secondary
deviation in concomitant conver
gent strabismus

Now, neither of these lines
can be seen and the direction of the line of vision is judged by
the position of the pupil Hence the greater the size of a
positive angle γ the more the eye will appear to look out
wards If the angle γ is negative the eye will appear to
look inwards Therefore in high hypermetropia there will be
an apparent divergent squint, in high myopia an apparent
convergent squint The latter is the more striking because
the emmetropic eye usually has a positive angle γ of 5°, thus
producing an apparent divergence of 10°, which however, we
are accustomed to regard as the normal position of the eyes.

Having decided that the case is not one of paralytic stra
bismus it is necessary next to show that it is real not merely
apparent This is easily done as follows The patient is told

to fix the surgeon's index finger, which
is held up at least two feet from the
eyes If it is held closer, as is too often
done, normal convergence will vitiate
the result The surgeon's left hand or
a screen is held in front of the patient's
right eye , the left eye will now be
accurately fixing the finger The screen
is then moved so as to cover the left eye,
fixation being now taken up by the right
eye If the right eye moves inwards
or outwards at the moment when it
takes up fixation there is a true squint ,
if it remains absolutely motionless the
squint is apparent only

Having now eliminated both para-
lytic and apparent strabismus, it is
almost certain that the case is one of
true concomitant squint (see, however,
p 581) In concomitant squint one
eye maintains fixation while the other
is adverted or abverted If in the test
just described the fixing eye is covered
by the screen, the deviating eye gene
rally moves outwards or inwards through
an angle equivalent to the angle of the
deviation in order to take up fixation
At the same time the eye behind the
screen moves inwards or outwards
through exactly the same angle (secon
dary deviation) If now the screen is
removed it will generally be found that
fixation immediately reverts to the first
eye Such a case is usually termed one
of *unilateral strabismus* In some cases
fixation is still retained by the second
eye If it is so retained for a con-
siderable period, *e g*, while the patient
blinks several times, the squint is said
to be *alternating* Inquiry will then
generally elicit the fact that the patient
sometimes squints with one eye sometimes with the other
indeed, this may be noticed while watching the patient
Usually an object towards the right in the field of vision will
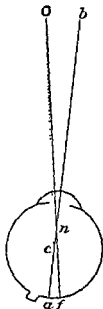
FIG 319—A p p a r e n t
strabismus *a b* optic
axis upon which the
refractive surfaces are
centred, *f*, fovea cen
tralis, *n* nodal point,
c, centre of rotation
O point of fixation
O c, line of fixation,
O n b angle *γ* it is
practically equal to
O n b which can be
measured In actual
practice the guide to
a b is taken from the
centre of the pupil,
a b does not usually
pass accurately
through the centre of
the pupil, so that the
result is always only
approximate The
angle *γ* is to the nasal
side in hypermetropia
and emmetropia

be fixed with the right eye, in the left of the field by the left eye   Occasionally patients with alternating strabismus can fix with either eye voluntarily, but usually they are unconscious which eye is fixing   Concomitant squint may be *constant*, or occur only at intervals—*periodic*

It has been mentioned that when the fixing eye is covered with the screen the deviating eye usually moves so as to take up fixation   In unilateral squints of long standing this eye may remain motionless and can only be moved into the primary position by moving the finger, a condition which is called *eccentric fixation* (*vide* p 571)   Since it occurs only with marked deviation of long standing there is generally no difficulty in distinguishing it from apparent squint

In performing the preliminary test to eliminate paralytic strabismus it will often be found that in true concomitant squint with considerable deviation the eyes do not move as much as usual in the direction opposite to that of the deviation. Thus, in convergent squint it may be very difficult to get the eyes to move outwards as much as normal, i e , so that the margin of the cornea lies under the external canthus   Similarly in divergent squint it may be very difficult to get the eyes to move inwards as much as normal, i e , so that the margin of the cornea is well covered by the internal canthus   This defective movement is commonly attributed to " insufficiency " of the external or internal recti respectively   In convergent strabismus it is probably due, not to any defect in the external rectus or its innervation, but to the fact that, fixation being dependent upon one eye, there is little stimulus to outward movement as soon as the point of fixation has passed beyond the field of fixation of this eye, i e , as soon as the nose cuts off vision of the finger   In many such cases the eye will move out completely if the finger is moved rapidly   In very young children it is better to turn the child's head in the opposite direction   in which case curiosity stimulates the child to keep up fixation   In divergent strabismus defective inward movement is sometimes due to mechanical causes, viz , the size of the myopic eye (*vide* p 581)

It has already been mentioned that in concomitant strabismus there is no diplopia   It may be present in the earliest stages, but is invariably absent in the later   This is due to psychological suppression of the image of the squinting eye   In most cases suppression is aided by actual defect, usually ametropia, in this eye, but such is not the complete explanation, since suppression of the image of the squinting eye is also the

rule in alternating squint, in which both eyes are frequently quite normal or have the same degree of ametropia. Suppression is doubtless aided in all cases by the peripheral situation of the image in the squinting eye, but there is no doubt that the seat of suppression is really in the brain, that is, in the interpretation of the stimuli reaching the brain from the eyes; those derived from the squinting eye are unwittingly neglected. The ability to exclude the impulses derived from the squinting eye is an important point in attempting to arrive at the rationale of concomitant strabismus. It follows from this fact that people with convergent squint have only uniocular vision, or, at most, very imperfect binocular vision.

Except in alternating strabismus the vision of the squinting eye is nearly always defective, which is partly due in most cases to errors of refraction. In convergent strabismus the eyes are nearly always hypermetropic, with or without astigmatism, and often the squinting eye has greater ametropia. There can be little doubt that some such inherent defect may determine which eye will deviate, though it is probably never the fundamental cause of the squint.

The vision in the squinting eye is often defective beyond any explanation derived from objective defects—ametropia, &c. In some such cases there is reason to believe that the defective vision dates from birth—*congenital amblyopia*. In all unilateral squints of long standing, very defective vision in the squinting eye is the rule. It is commonly attributed to the prolonged suppression of the images derived from this eye, and is hence called *amblyopia ex anopsiâ*. This explanation is not altogether satisfactory, since cases are well known in which vision has been excluded for many years by congenital cataract, yet is quite good after successful operation. The vision in the amblyopic eye is often reduced to 6/60, and may be reduced to counting fingers. Cases of recovery of sight after loss of the fixing eye have been recorded, but unfortunately this result certainly does not invariably follow. The visual acuity may be greater in the false position than when the retinal image falls upon the fovea (eccentric fixation with "false macula," abnormal retinal correspondence). This results in "false projection," or all power of fixation may be lost by the amblyopic eye.

It has already been mentioned that the gross movements of the eyes are nearly or quite perfect in concomitant strabismus. This applies equally to dynamic convergence and accommodation. The eyes start in an abnormal position, and normal

movements are superposed   Thus in fixing a new object, the
normal amount of dynamic convergence is superposed upon the
abnormal static convergence or divergence

Concomitant strabismus always commences in childhood,
generally in infancy   It may become manifest after a fright,
an attack of whooping cough, measles or other debilitating
illness, and is often popularly attributed to some such cause
It must be carefully distinguished from the squinting which
normally occurs during the first few weeks of life, before fixa
tion is developed (*vide* p 564), this is not concomitant Many
important factors in the ætiology of concomitant strabismus are
known and a proper appreciation of them is essential to rational
treatment   No theory of the fundamental causation which
has yet been advanced satisfactorily explains the condition

Attention was early drawn by Donders to the common asso-
ciation of convergent strabismus with hypermetropia   He
explained the relationship by the fact of the normal association
of convergence and accommodation (*vide* p 546)   Hyper-
metropes have to exercise an effort of accommodation to see
distant objects, still more to see near objects   The effort of
accommodation is associated in the normal person with a corre
sponding effort of convergence If this rule be supposed to hold
good for hypermetropes, the strong accommodation may be
regarded as inciting an effort of convergence which is excessive
for the actual point of fixation   The hypermetrope is therefore
in a dilemma   He must either converge accurately for the
object, in which case he will not accommodate sufficiently to
see it clearly   or he must accommodate accurately for it, in
which case he will converge too much   This will cause homony
mous diplopia, unless he is able to suppress the image of one
eye, which is exactly what the patient with convergent
strabismus does   Regarding divergence as negative converg
ence, the association of divergent strabismus with myopia is
explained by the same theory

There is no question that this factor is one of great import
ance, as is shown by the cure of some cases of squint by suit-
able correcting glasses   It is not, however, the fundamental
cause of squint, for if it were (1) all uncorrected hypermetropes
would have to squint, (2) there would be ametropia in all
cases of concomitant strabismus   The latter corollary is
found to be false, for convergent strabismus, other than
apparent strabismus is occasionally found to be associated
with myopia, and in alternating strabismus there is often little
or no ametropia

In spite of these facts the great importance of the association between accommodation and fixation must be strongly insisted upon Convergent strabismus most frequently develops between the ages of two and six, i e , just at the period when the fixation of near objects throws a strain upon accommodation It is often periodic at this stage, and noticed only when near objects are looked at Moreover, there is an undoubted tendency for the deviation in all cases of convergent strabismus to diminish with age, i e , with the diminution of accommodation The relative infrequency of convergent squint in adults, compared with its frequency in children, cannot be explained solely by the fact that many cases undergo successful treatment It may be remarked that the amblyopia persists in the formerly squinting eye hence in every case in which satisfactory objective evidence of the cause of defective vision in one eye cannot be discovered, the patient should be asked if he ever squinted

As already mentioned, greater ametropia in one eye, opacities in the refracting media, intraocular disease, and so on, are never the fundamental cause of strabismus, though they may determine the particular eye which loses fixation This is especially the case when concomitant squint is preceded by latent squint ($q\ v$) It is easy to understand that when there is disturbance of muscular equilibrium which can only be overcome by special effort, any slight defect in one eye may determine the development of a manifest squint

The application of Donders' theory to divergent strabismus associated with myopia has been mentioned Here, since near objects are seen with little or no accommodation, the impulse to convergence is too weak Since infants are rarely myopic, this form of divergent squint does not develop in early childhood There are other factors besides deficient accommodation which tend to produce divergence in myopia One is the mechanical conditions of the myopic eyeball, which, being abnormally large and long, adapts itself to the axis of the orbit Further, the internal recti act under mechanical disadvantage from the same cause Moreover, in very high myopia the far point of the eye is so close to it that it is impossible for convergence to be effectual—it becomes impossible to see the object with both eyes at the same time The better eye is then used and the other is allowed to take up the position of rest, which is usually one of divergence Such a strabismus may remain periodic for near work only for many years , in other cases it becomes constant

Spontaneous cure rarely if ever occurs in divergent strabismus, which tends to increase with age

The deviation in convergent squint is not always quite horizontal   in many cases the eye deviates upwards as well as inwards   In some cases the deviation is still more unusual, and the movements of the eye are quite abnormal   In most of these cases there is a congenital mal insertion or defective development of one or more of the extrinsic muscles, and the squint dates from birth (*vide* p 586)

Concomitant strabismus has proved a fertile field for conjecture   There are several points bearing upon the subject which are obscure, such as the development of fixation and of binocular vision, the occurrence of congenital amblyopia, and of amblyopia ex anopsia, and so on   Many theories relating to these points have been stated and restated so frequently that they are accepted as facts   In reality, many are not susceptible of demonstration, and none have been proved   The theorist on strabismus accepts the ' facts " which fit his theory, and rejects the remainder

The prevailing theory at the present time is that strabismus is due to defect of the fusion faculty, or the capacity of combining psychologically the impressions derived from the two eyes   Some authors go so far as to hypothesise a ' fusion centre ' in the brain   No one will deny that the fusion of the images derived from the two eyes in binocular vision is a mental though unwitting act, and that it has a physical basis   This
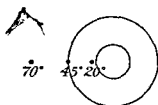
FIG 320—Diagram of the position of the corneal reflex as a guide to the angle of the squint

physical basis is a set of accurately co ordinated nerve impulses   Binocular vision, then, depends upon the accuracy of co ordination of these impulses, and this is a function of the nerve complex as a whole, not of any particular ' centre "   It is indeed possible that the strabismus is caused by inco ordination of the afferent impulses upon which binocular vision depends, though this advances the true ætiology of the disease but little   It is just as probable that the inco ordination or deficiency of the afferent impulses is a result of the strabismus, which is itself due to some other cause , or both may be due to a common cause

In every case of concomitant strabismus the angle of the deviation should be measured, so that the mode of treatment

may be determined and its effects accurately gauged A rough indication of the angle of the squint can be obtained from the position of the corneal reflex when light is thrown into the eye with the ophthalmoscope mirror (Fig 320) The light is thrown in from a distance of about two feet, and the patient is told to look at the mirror, an infant does this reflexly In the fixing eye the corneal reflex will be in the centre of the pupil, or slightly to the inner side if there is a large angle γ, to the outer side if there is a negative angle γ The light is then turned on to the squinting eye If the reflex is about half way between the centre of the pupil and the corneal margin, there is a deviation of about 20°, if it is at the corneal margin, about 45° This test is only a rough one

The best test in children is with Priestley Smith's tape (Fig 321) It consists of a tape 1 metre or 60 cm long, with a ring at each end To one ring a second tape is attached, having a tangent scale upon it The graduations are, of course, different, according to the length of the first tape At the other end of the tangent tape is a small weight The measurement is carried out in the dark room The free ring is held by the patient or an assistant on the cheek immediately below the fixing eye The surgeon passes one finger of the hand, which also holds his ophthalmoscope, through the other ring, and keeps the tape taut With his disengaged hand he holds the tangent tape at right angles to the distance tape, at the same time holding up the index finger as an object of fixation The light from the ophthalmoscope is thrown into the squinting eye,

FIG 321—Diagram of Priestley Smith's tape for measuring the angle of squint R right eye with internal squint L, left eye, O, ophthalmoscope, O F, graduated tape, F, fixation point (observer's finger), W, weight The angle measured is O L F, which is equal to O R R, the angle of the squint

and the patient is told to look at the fixation finger This is moved along the tangent tape until the corneal reflex is in the centre of the pupil The angle of the squint is then read off on the tape The direction in which the tangent tape is held, whether to the surgeon's right or left, depends, of course, upon the side of the squinting eye and the nature of the squint, whether convergent or divergent This test is the best yet devised for small children

The angle of deviation can also be measured with the perimeter (Fig 322) The squinting eye is placed at the centre of the arc and the patient fixes an object six metres away, situated slightly over the position of the ordinary fixation spot of the perimeter The arc of the perimeter is turned to the horizontal position on the side towards which the squinting eye is directed The surgeon passes a candle flame along the arc until the corneal reflex is in the centre of the cornea of the squinting eye He then reads off the angle of the squint on the arc If extreme accuracy is desired, the angle γ should be measured and allowed for It is done by covering the sound eye and making the patient fix the fixation spot of the perimeter with the squinting eye The candle flame is again carried along the arc until the corneal reflex is again in

the centre of the cornea The angle γ is read off on the arc The method is not suitable for children, and can only be employed with intelligent adults One objection to it is the tendency to fix the ordinary fixation spot of the perimeter instead of a distant spot in the same line of vision If this mistake is made errors arise, more particularly because the amount of dynamic convergence exerted in these cases is not always the same as with normal eyes
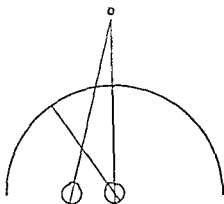
Fig 322 —Measurement of the angle of squint by the perimeter

The angle of deviation can also be conveniently measured

on a tangent scale set against the wall the corneal reflex of a candle flame being again used as a guide

Treatment   The routine treatment of a case of concomitant convergent strabismus in a child is as follows —

(1) *Preliminary*   Record the distant vision of each eye if the child is not too young the angle of the deviation &c Order ung atropine 1 per cent three times a day for at least four days   At the end of this period estimate the error of refraction by retinoscopy and confirm the result subjectively if possible   reliance should be placed on the retinoscopy rather than on subjective tests   Again measure the angle of the squint which is likely to be less under atropine than without a mydriatic   Order the full correction for constant use   A smaller correction for the effect of atropine should be made than in hypermetropia without squint   If the error is considerable I usually subtract only 0 5 D for atropine instead of 1 D , if the error is small I order the full atropine correction to start with   Great care must be taken to correct all astigmatism especially in the squinting eye   The patient should be re examined in a month s time

If the child is less than two years old I do not order glasses except in rare cases   Some surgeons order them in all cases. I prefer to eliminate accommodation by keeping both eyes under the influence of atropine   the 1 per cent ointment need be applied only once a day   The child should be examined at regular intervals until it is considered advisable to order glasses

(2) *Occlusion of the Fixing Eye*   After the glasses have been used constantly for a month the child is again examined   The vision is tested and the angle of the squint again measured   The treatment now depends upon the condition of the vision in the squinting eye   If as is usually the case this eye is amblyopic an effort should be made to improve the vision in it by continual exercise   In order that this eye may be used the other must be prevented from seeing or at any rate from seeing clearly   Partial occlusion may be done by placing a pad of cotton wool under the glass in front of the fixing eye for a certain period e g ½—1 hour three or four times a day This method is liable to be neglected or carried out inefficiently   A better method is to order the instillation of atropine *into the fixing eye only* once a day   This eye will then generally be used only for distant vision the squinting eye being used for seeing near objects   Complete occlusion is effected by a patch of isinglass plaster shaped so as to cover the eye   A

second smaller piece is applied to the adhesive side of the larger piece so that the smooth surface is towards the lids and an adhesive margin, half an inch wide, is left round the edge This is stuck down to the temporal region, the forehead, the bridge and side of the nose, and across the cheek, over the malar bone a small air vent is left   The plaster is changed every third day   Occlusion should be absolute   and may have to be continued for six to twelve weeks or until the vision has improved to 6/12 or 6/9, when the visual acuity is sufficient for orthoptic training   The child is examined at intervals of a month or two, and any improvement in vision in the squinting eye   as well as any change in the angle of deviation, carefully recorded   In some cases the deviation becomes transferred to the occluded or atropized eye   this is a good sign, as it indicates that the vision with the originally squinting eye is only slightly worse than that of the fixing eye

(3) *Orthoptic*   The further treatment depends upon the size of the angle of deviation   the condition of vision in the squinting eye   and a variety of other factors which differ in each case   An attempt is made to cultivate binocular vision and stereoscopic fusion by *orthoptic treatment*   This consists essentially in specially devised exercises   It has one overwhelming argument in its favour, viz, that when successful it cures the squint   The cure is complete, i e, the patient is placed in the same condition as a normal person, his eyes are straight and he has binocular vision   No other treatment can be said to cure the disorder   The eyes can be put straight, but this cures only the deviation   the other elements of the disorder remain unaffected

There are three stages in orthoptic treatment   (1) the production of simultaneous vision with the two eyes   i e, the unmasking of diplopia, (2) the production of binocular vision   i e, the fusion of two halves of the same object presented simultaneously to the two eyes respectively, and (3) the production of stereoscopic vision, i e, the fusion of two images of the same object seen in perspective, resulting in the perception of relative distance of parts, solidity, and relief   The second stage will be facilitated if the two images are close together and hence orthoptic treatment may demand operative treatment at an early age

Unfortunately orthoptic treatment is extremely tedious and requires prolonged and very persevering efforts   In many cases it is useless to attempt it, and in all cases it is useless

unless carried out systematically and thoroughly For the details of the treatment monographs on the subject must be consulted It has been considerably elaborated of recent years, and very encouraging results have been obtained Few surgeons can spare the time to undertake it, but it should always be carried out under their supervision

(4) *Surgical* treatment is indicated when the residual angle of squint is 10° or more when wearing correcting glasses, and in children between four and five years of age when orthoptic training has failed to bring the eyes parallel

Orthoptic training is an important preliminary to operation, and should be resumed as soon after as possible When the angle of squint is 25° or more preliminary orthoptic training is generally waste of time, and operation should be undertaken early The best results are in those operated on between four and six years of age Postponement until the child is ten or more usually results in the permanence of amblyopia and failure to establish binocular vision The operation is then purely cosmetic

Very free tenotomy of the internal rectus tendon and its expansions into Tenon s capsule has often been followed in the past by divergence and retraction of the caruncle and plica semilunaris owing to failure of reattachment to the globe Guarded tenotomy, using retention stitches, in children and recession in adolescents and adults are more accurate and reliable The internal rectus should not be recessed more than 5 mm lest weak convergence occur, leading to discomfort in reading and near work and to headaches An internal rectus recession of 5 mm will correct about 20° of squint Considerable experience is required to assess the amount of recession and advancement needed in different cases

If the deviation is 10° to 15° tenotomy or recession of the internal rectus of the squinting eye should be performed This will cure the deviation or reduce it to a negligible quantity

If the deviation is more than 10° to 15°, advancement of the external rectus of the squinting eye, usually with tenotomy of the internal rectus of the same eye, will be necessary If the deviation is large advancement of the external rectus should always be accompanied by tenotomy of the internal rectus This avoids an appearance of enophthalmos by allowing rotation of the globe approximately around the centre rotation of the eye A general anæsthetic is to be avoided if possible, since the position of the eyes varies so much in different stages of anæsthesia that it gives no criterion of

final position after the anæsthetic has passed off Very good
results can, however, be obtained by an experienced operator
if he keeps firmly in mind the amount of the deviation and
ignores the position actually present under the anæsthetic
With pantocain only the operation is painless, except when
tension is put upon the muscle It is almost impossible to
avoid slight tension during certain stages, but it need only be
momentary

It is possible to operate on some quite young children under
local anæsthesia by keeping up a conversation with them
With those who are nervous or troublesome intravenous
pentothal sodium anæsthesia works well It should be given
by an experienced anæsthetist, after a preliminary sedative
instillation of pantocain and adrenaline, and injection of
novocain into the muscles involved

The treatment of alternating concomitant convergent
squint without appreciable error of refraction is purely
cosmetic These patients have no binocular vision, and it is
useless to attempt to develop it unless the case is seen when
the patient is very young, or immediately after the squint
has been first noticed Usually there is considerable deviation,
so that an advancement operation is required It should be
postponed until a perfect result can be guaranteed, i e, until
the operation can be performed with local anæsthesia

In rare cases the patients develop diplopia after the eyes
have been put straight This may be due to a "false macula"
(*vide* p 571) but also occurs with alternating squints It is a
very troublesome complication, since it usually persists for
weeks or months, and is very distressing to the patient

The treatment of concomitant divergent strabismus is similar
to that of the convergent type The refraction must be first
carefully corrected, and it is advisable to order a full correction
for constant use unless the myopia is very high Tenotomy
of the external rectus is seldom indicated in these cases because
the benefit derived is too slight , it will not correct much more
than 5° deviation Hence advancement of the internal rectus
is usually necessary No operation is advisable in very high
grades of myopia, since the size of the eye may render success
mechanically impossible (*vide infra*)

In divergent strabismus slight over-correction is indicated,
for these eyes show a great tendency to revert to their former
position In convergent strabismus the deviation should be
fully corrected only in adults, on account of the tendency of
the deviation to diminish *pari passu* with the loss of accom

modation (*vide* p 573) Moreover, slight convergence is less unsightly than divergence

Divergent Strabismus other than Concomitant and Paralytic There are cases of divergent squint which are not paralytic, nor are they strictly concomitant Some are very nearly allied to the true myopic divergent squint and may arise from it, *e g*, the divergence of the worse eye after binocular fixation has been completely abandoned Similarly the mechanical divergence of extreme myopia is neither concomitant nor paralytic

Another form of divergence, allied to the unilateral divergence in unequal myopia is met with occasionally in any form of anisometropia in which the difference in refraction between the two eyes is great In these cases, which are seldom susceptible of full optical correction (*vide* p 532) one eye only is used for fixation It is not surprising therefore that the unused eye assumes a position of rest, which is usually one of divergence It is more surprising that relatively few such cases of anisometropia develop a manifest squint When a squint is developed the patient not infrequently complains of diplopia, which is the more trying the less the divergence These cases are difficult to treat Prolonged use of the fullest possible correction aided by stereoscopic exercises, should be tried first If it fails tenotomy of the external rectus of the diverging eye may effect a cure in slight deviations In other cases an advancement is indicated in such cases extreme delicacy of manipulation is required Operation undertaken for cosmetic reasons may sometimes induce or increase diplopia by approximating the true and false images , it is usually permanent in these cases and exceedingly distressing

Finally, a blind eye diverges sooner or later

OPERATIONS ON THE EXTRINSIC MUSCLES

Simple Tenotomy Instruments required speculum, fixation forceps, flat strabismus hook (Moorfields' pattern), tenotomy scissors *Local anæsthesia suffices in all but very young patients a few drops of adrenaline (1 in 1 000) may be instilled with advantage*

The conjunctival sac having been douched, and the speculum inserted, the conjunctiva is seized over the muscle and a vertical incision, 8—9 mm long, is made with scissors It must be remembered that the internal rectus is inserted nearest to, the external farther from, the corneal margin (*vide* p 539) The

tissue underlying the conjunctiva at the lower border of the muscle is then seized with the forceps and incised, care being taken to hold the scissors so that they are tangential to the globe If this is properly done Tenon's capsule is opened The hook is now taken in the right hand, which still retains the scissors, and the point is introduced into the opening in Tenon's capsule It is passed backwards, then upwards between the muscle and the sclerotic In this manœuvre the point of the hook must be kept firmly against the globe The point of the hook appears at the upper border of the muscle It is freed from any conjunctival or subconjunctival tissue which may cover it The hook is drawn forwards until it lies close under the insertion of the muscle The hook is transferred to the left hand The point of one blade of the scissors is introduced along the hook below the tendon, and the muscle is divided between the hook and the sclerotic The hook should be introduced again and moved about in such a manner that any attachments which remain may be caught up and divided
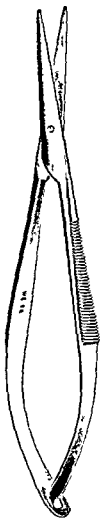
The conjunctiva is sutured with silk sutures and a pad and bandage are worn for two days, the eye being freely irrigated with boric acid lotion

With the exception of a small puncture in the conjunctiva the whole operation can be performed subconjunctivally by an expert This method has the advantage of preventing so much retraction of the caruncle in tenotomising the internal rectus as usually follows tenotomy by the open method It is less easy and slightly more dangerous

No attempt should ever be made to obtain a greater effect from tenotomy of the internal rectus than 10°, of the external rectus 5° If a greater effect is desired an advancement of the opponent must be performed

Guarded Tenotomy of the Internal Rectus Instruments required
Lang's speculum (Fig 118) 2 pairs of conjunctival block forceps

FIG 323—Spring SCISSORS

(Fig 119), fixation forceps, 1 c c hypodermic syringe, 1½-inch hypodermic needle, spring scissors (Fig 323), needle holder (Fig 324), 3 sutures of 000 black silk on conjunctival needles, 6 bull-dog forceps for clamping sutures, 4 mosquito pressure forceps for gauze swabs, straight probe, spirit lamp, 2 strabismus hooks (Fig 276), pair of dividers, steel rule graduated in milli metres, mapping pen with terminal 3 mm bent at right angles, gentian violet for marking, closed tubes of six 0 catgut sutures on eyeless needles, and No 1 black sutures on eyeless needles

A curved incision is made with scissors in the conjunctiva with its convexity towards the cornea over the internal rectus The flap is undermined by passing scissors under it towards the inner canthus, the blades being then opened ("spreading") Black 000 silk sutures are then inserted into the edge of the flap, which is reflected by clamping the sutures to the towels The subconjunctival tissue is pushed towards the nose with a gauze swab, and the muscle, covered by Tenon s capsule, ex posed Tenon's capsule is then seized with forceps just above and below the insertion of the muscle and button holed with scissors The capsule is slit for 7 mm along the upper and lower edges of the muscle Any bleeding points are touched with a probe heated in the flame of the spirit lamp Tenon s capsule covering the muscle should be preserved The point of a strabismus hook is passed into Tenon's capsule at the posterior limits of the incisions and retracted Dividers measur ing the amount desired to set the muscle back are placed along the upper and lower borders of the muscle, the distance measured off from the tendon insertion, and marked on the sclera with the mapping pen (One mm recession corrects about 4° deviation) Two mm behind the insertion of the tendon two sutures of No 1 black silk with an eyeless needle threaded at each end are passed at right angles to the long axis of the muscle fibres for 3 mm each (Fig 325) These mattress sutures later invert the cut end of the muscle on to the sclera The sutures are held in a clamp and the tendon divided with scissors The cut end of the muscle is allowed to slip back to the level of the marks on the sclera The sutures are then passed through the stump of the tendon, brought through the conjunctiva, and tied whilst the assistant keeps the cut end of the muscle at the right level

FULL SIZE
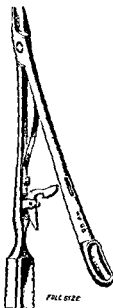
Fig 324 — Silcock s
needle holder

by holding the sutures with plane forceps just behind the tendon stump until the knot is tied (Fig 326) All blood is swabbed up Tenon's capsule is stroked back into position, and
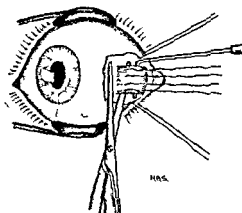
Fig 325 —Guarded tenotomy of internal rectus sutures inserted

the conjunctival incision closed by four interrupted sutures The eye is irrigated with saline a drop of puroclein instilled, and both eyes covered with pads and bandage The conjunctival
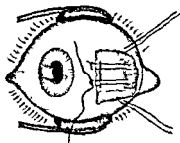
Fig 326 —Guarded tenotomy of internal rectus sutures tied

sutures may be removed in forty eight hours but the mattress sutures are left for fourteen days

Recession of the Internal Rectus is performed in a similar manner Two 000,000 catgut sutures on eyeless needles are

passed through the upper and lower edges of the muscle 2 mm
behind its insertion in the so called "whip stitch" fashion
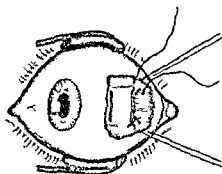
Fig 327 —Recession of internal rectus

(Fig 327) The tendon is divided and the stitches are passed
through the superficial layers of the sclera at right angles to the
long axis of the muscle
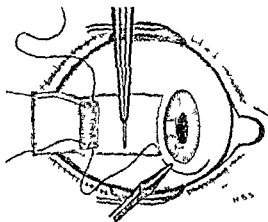
Fig 328 —Advancement of external rectus

Advancement of the External Rectus An incision is made
2 mm behind and concentric with the corneoscleral junction
in front of the insertion of the muscle The conjunctiva is
then undermined by "spreading" (vide supra) No 1 black

silk sutures on eyeless needles are passed through the posterior edge of the incision, one above and one below. These are held up and the conjunctiva incised backwards for 4 mm from the upper and lower ends of the incision. The flap is reflected to the temporal side and the sutures clamped to the towels. The muscle is exposed in the same manner as in guarded tenotomy (*vide supra*). A strabismus hook is passed between the muscle and sclera and the length of muscle and tendon for resection marked off (1 mm advancement corrects about 2° deviation). No 1 black silk whip stitch sutures are passed through the upper and lower edges of the muscle 2 mm behind the gentian violet mark and ensnaring a breadth of 2 5 mm of the muscle fibres. The muscle is divided at the mark the distal part being held in fixation forceps so as to steady the globe whilst the scleral sutures are inserted. The eyeless needles carrying the whip-stitch sutures are passed through half the thickness of the sclera transversely to the long axis of its fibres at the anterior marked spots (Fig 328). It is essential to obtain a firm hold on the sclera, and in order to do this the needle is first passed almost vertically for 0 5 mm and then turned slightly towards the surface. It is driven through about 1 mm by pressure *in the line of curvature of the needle*. When the point emerges assistance may be afforded by counter pressure with a fine plastic hook around the needle point until sufficient of the needle has emerged for a grip to be taken of it by the needle holder. The tendon is then divided at its insertion, the shortened muscle drawn forwards and the sutures tied. All blood is swabbed up, and the conjunctival incision closed with 000 black silk sutures.

CONGENITAL DEFECTS

One or more of the extrinsic muscles may be absent as a congenital defect or may be abnormally inserted into the sclerotic. In some cases the condition has been proved to be due to the absence of the motor nervous mechanism. The position of the eyes and their movements may be very varied, but sometimes resemble those of an ordinary internal squint. In the latter case peculiarities of movement, *e g*, in and up instead of inwards, can usually be elicited. When each eye is made to fix successively, the movements of the eyes are often quite different from each other. There is never double vision and muscular contracture does not occur. There is often congenital ptosis (*q v*) not infrequently of the hereditary type, and sometimes nystagmus.

LATENT STRABISMUS OR HETEROPHORIA

It is found in some apparently normal persons that in the screen test (*vide* p 550), when the screen is removed from before one eye, that eye moves slightly inwards or outwards to regain binocular fixation , if the screen is placed in front of the other eye and then removed this eye also moves slightly inwards or outwards respectively to regain fixation   When both eyes are fixing there is no deviation   Such a squint is called a latent squint or, in opposition to the normal condition of orthophoria, heterophoria   If the latent squint is one of convergence the condition is called esophoria, of divergence exophoria   Sometimes one eye is higher than the other , this condition is usually called hyperphoria   as a matter of fact it is impossible in these cases to be sure whether there is absolute hyperphoria of one eye or hypophoria of the other, the condition being relative only

It must be concluded that when the eyes are screened they take up a position of rest, the extrinsic muscles exercising merely the tone normal to them at the time of examination In cases of latent squint the position of rest is not orthophoria with the visual axes parallel but heterophoria, with some deviation of the axes   During normal vision the requirements of binocular vision demand a suitable readjustment of the visual axes which can be brought about only by tonic con traction of certain muscles—in esophoria of both external recti, in exophoria of both internal recti   This involves a perpetual strain, which often manifests itself as asthenopia As might be expected the deviation is liable to become manifest in conditions of bodily fatigue and to vary in amount from time to time   Some periodic squints are due to this cause, and the periodicity may be rhythmic   Thus a child may squint in the evening when he is tired , after a good night's rest the squint has disappeared, and may not return until the second or third day, the sequence being accurately repeated Often latent squints give no trouble until school time arrives or adult life is reached   Here the demands of near vision increase the strain   No symptoms arise perhaps until after reading or writing for an hour or two   Then " the letters seem to run together "   This is due to relaxation of the over strained muscles , the eyes momentarily assume the position of rest, and diplopia, which is not realised as actual double vision, causes blurring of the print   With an effort the blurring

is overcome, but eventually this becomes impossible, headache supervenes, and the work has to be abandoned

Analysis of the cases shows that slight eso- and exo phoria are quite common and give rise to little or no trouble, which is not difficult to understand when it is remembered that over action of both internal recti is physiological in ordinary convergence on near objects These muscles are therefore accustomed to act together and little strain is felt   The same is true in less

degree of the external recti Only when the deviation is great —5° to 10° or more—is asthenopia frequently present   Very slight degrees of hyperphoria, however, almost invariably cause extreme discomfort, for in these cases over action of muscles which are not accustomed to work together is necessary in order to keep the visual axes in the same plane   For instance, in the primary position of the eyes there must be over action
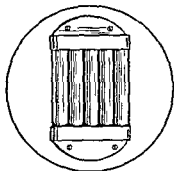
Fig 329 —Maddox rod

of one superior rectus and inferior oblique, combined with over-action of the other inferior rectus and superior oblique, and the readjustment in other positions of the eyes must be very complex

It may be impossible to discover slight degrees of heterophoria by the screen test   More delicate tests have therefore been devised   All depend upon disassociating the two eyes The simplest method is that of so altering the appearance of the retinal image in one eye that it affords no stimulus to fusion with the image of the other eye

The Maddox Rod Test   The patient is placed six metres from a candle or bright spot of light in a dark room   A Maddox rod (Fig 329), which consists of four or five cylinders of red glass side by side in a brass disc, is placed in the trial frame before one eye   The spot of light seen through the red cylinders appears as a long red line   If the cylinders are placed with their axes horizontal the red line will be vertical If there is orthophoria the bright spot will appear to be in the centre of the vertical red line , if there is eso- or exo-phoria the red line will be to one side of the spot   The angle of the deviation is measured by the strength of the prism which it is necessary to place in front of the Maddox rod in order to bring

the red line and the spot together The nature of the deviation is indicated by the position of the base of the prism whether out or in

The Maddox rod is then turned round so that the cylinders are vertical, the red line will now be horizontal If there is no hyperphoria the line will pass through the bright spot If there is hyperphoria the red line will be below or above the spot according as the relative hyperphoria is in the eye with the rod in front of it or in the other The amount of deviation is measured either on a tangent scale or by the strength of the prism required to correct it

The Red Green Test A vertical slit covered with red glass above and green glass below is illuminated from behind and viewed by the patient through reversible spectacles containing a red glass in one eye and green in the other The glasses are chosen such that the red glass absorbs all rays transmitted by the green and *vice versa* With orthophoria the two lights are seen in their proper position with heterophoria they are displaced but may become replaced by muscular effort Disappearance of one light indicates complete suppression of the image of the other eye

The Diaphragm Test In its original form in Remy's diploscope letters are viewed on a stereoscope frame through two slits in a diaphragm interposed between the eyes and the letters In Bishop Harman's diaphragm test letters or numbers are viewed in a similar manner through a single central slit the width of which is adjustable The width of the slit is shown on an arbitrary scale thus enabling a numerical record of the examination to be made

The Red Green Test and the Diaphragm Test have been adopted by the Royal Air Force for their examination of candidates (*vide* p 700) for it has been found that latent squint is a potent cause of bad landings

The deviation in latent squint is often different in near vision from that in distant so that both must be tested The deviation in near vision is tested by means of a special card (Plate XXI) A strong prism—about 12°—is placed base down or up before one eye In orthophoria the arrows are exactly in the same vertical line In eso or exo phoria the lower arrow points to a number in the upper scale This number gives the angle of deviation which may be confirmed by counteracting the deviation with a prism base in or out before one eye The Maddox wing test or the Bishop Harman diaphragm test (*vide* p 701) is a convenient method of applying this test

Besides the actual measurement of the deviation in latent strabismus forcing the strength of the muscles involved should also be tested by forcing them to a maximum effort against prisms With the patient seated six metres from a candle the highest prism, base down before the right eye still permitting of single vision, gives the range of superduction of that eye   Subduction and abduction can be measured in the same manner Adduction gives less concordant results   The normal limits of super and sub-duction are 1 5° to 2 5°, of abduction 4° to 5°

Allied to these defects, though not strictly speaking a latent squint is insufficiency or weakness of convergence   It will be revealed by the ordinary tests of motor balance   If there is more exophoria or less esophoria in near vision than in distant there is insufficiency of convergence   The majority of cases have orthophoria or esophoria for distance, but exophoria for near work   Most of them have hypermetropia, but it is not uncommon in myopes   Simple tests for convergence are described in the examination of candidates for the Royal Air Force (*vide* p 699)   The defect causes asthenopia in near work

Treatment   The lower degrees of esophoria, and to a less extent of exophoria, cause no symptoms and need no special treatment   Slight exophoria often causes symptoms in young adults much engaged in near work   It is relieved by suitable prisms bases in   if the general health improves, or the amount of near work is diminished, the prisms can be dispensed with later   Hyperphoria is most likely to cause asthenopic symptoms   It is corrected by ordering suitable prisms to be com bined with the glasses which correct any refractive error   If the spherical error is sufficiently great the prismatic effect may be obtained by decentring the lenses   The total prismatic error should be divided equally between the two eyes in ordering the correction   Thus, if there is hyperphoria of 3° as measured by a 3° prism base down before the left eye, a prism of 1½° is ordered before each eye, base up for the right, base down for the left   When this treatment does not succeed, and the deviation is considerable, tenotomy of the superior rectus may be necessary, but such cases are rare, and operative interference should not be lightly undertaken, for it is apt to be disappointing

The rational treatment of large degrees of eso or exo-phoria consists in exercising the weak muscles against prisms   This is usually only temporarily beneficial, but the muscles can be kept in good order by repeating the exercises at intervals   The

asthenopia can be relieved by ordering prisms to correct the defect, i e, prisms with their bases directed in the opposite sense to those used for exercise This should be avoided except in such cases as those already mentioned, since it generally tends to increase the defect, so that stronger prisms have to be ordered from time to time In severe cases a course of orthoptic exercises should be given and operative interference may be indicated

Insufficiency of convergence may be treated by prism exercises The following simple exercise is often sufficient without having recourse to prisms Any error of refraction is corrected with glasses which are ordered to be used constantly While reading the patient gradually brings the book nearer and nearer, until the print becomes blurred He then slowly moves the book back to ordinary reading distance The process is repeated At about every tenth line the patient looks into the distance, so as to relax his accommodation and convergence Two or three pages should be read in this manner three or four times a day for several weeks The course is repeated as often as necessary More effective are orthoptic exercises with stereoscopic apparatus

If convergence training fails prisms base in must be ordered with the reading glasses Care must be taken not to over correct presbyopia (vide p 536)

SECTION VI

SYMPTOMATIC DISEASES OF THE EYE

CHAPTER XXIX

Ocular Manifestations of Diseases of the Nervous System

MANY diseases which primarily attack other parts of the body give rise to ocular symptoms, and not infrequently first come under the observation of the ophthalmic surgeon   At the risk of some repetition I propose briefly to review the most important ocular manifestations of such diseases

The ocular signs of nervous disease often appear superficially to be complicated and confusing   In most cases they are readily explained by the anatomy of the part of the nervous system involved

Tabes Dorsalis   Primary Optic Atrophy (vide p 398) occurs in about 10—20 per cent of cases of locomotor ataxia   It is about twice as common in men as in women, most frequent between thirty and fifty years of age, and may precede the appearance of typical tabetic symptoms by some years   It is commonest in the pre ataxic stage, but it is not true that optic atrophy deters the development of ataxy or exercises any beneficial influence   The onset is gradual, leading to total blindness in two to three years or more   Pallor of the disc may precede the failure of vision by a considerable period, never the reverse   The affection of one eye usually precedes that of the other by a few months, rarely longer   The disease is probably a primary neuronic degeneration, starting in the ganglion cells of the retina, which would account for the bad prognosis (cf *Disseminated Sclerosis*, p 636), though there is some evidence that it may be due to intracranial involvement of the nerve and chiasma

The *fields* show progressive contraction, *pari passu* with the failure in central vision   It is rare for the failure of sight to commence with a central scotoma   thus differing from the

onset in disseminated sclerosis, though Fuchs has shown that
it occurs (*vide* p 400)   Two types of field are met with
(1) General concentric shrinkage, the colour fields for red and
green being very early lost, and central vision much impaired ,
(2) Irregular sectorial defects, which are sharply defined but
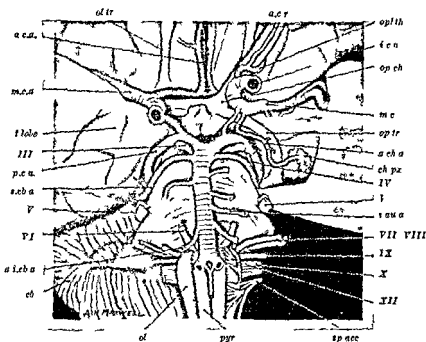
Fig 330—Relations of the cranial nerves to the arteries at the base of
    the brain   *a c r* arteria centralis retinæ , *ophth a* ophthalmic
    artery   *i c a* internal carotid artery   *op ch* optic chiasma   *a c a*
    anterior cerebral artery   *m c a* middle cerebral artery   *op tr* optic
    tract   *a ch a* anterior choroid artery   *ch px* choroid plexus
    i au a internal auditory artery   *sp acc* spinal accessory nerve
    pyr pyramid   *ol* olive   *cb* cerebellum   *a i cb a* anterior inferior
    cerebellar artery   *s cb a* superior cerebellar artery   *t lobe* temporal
    lobe   (Eugene Wolff   Anatomy of the Eye and Orbit   Lewis
    London)

gradually spread though central vision may be quite good
Defective dark adaptation and coloured vision have been
described as early symptoms of tabes

The characteristic pupillary signs include the so called
spinal miosis, the Argyll Robertson pupil reaction, inequality
of the pupils, and distortion of the pupillary aperture   These
signs are found in other diseases, and are to be regarded as
signs of syphilis of the central nervous system rather than

as pathognomonic of tabes Their combination is of great diagnostic significance Argyll Robertson pupils are found in 70 per cent of tabetics and are almost invariably bilateral Unequal pupils are found in 30 per cent of tabetics but are still more frequently met with in general paralysis of the insane Ophthalmoplegia interna, *i e*, paralysis of the sphincter iridis and of the ciliary muscle, occurs in about 5 per cent of tabetics and is generally unilateral It is due to a lesion in the nucleus of the IIIrd nerve Cycloplegia without mydriasis, or *vice versâ*, is rare

The Myotonic Pupillary Reaction resembles the Argyll Robertson pupil but occurs in the absence of all signs of syphilis It is characterised by inaction of the pupil to the light stimulus and slow reaction and recovery to convergence (Foster Moore) It is usually unilateral Tendon reflexes may be normal or impaired It differs from the true Argyll Robertson pupil in the sluggishness of the convergence reaction, and the fact that the tonic pupil is always larger than its fellow, whereas the unilateral Argyll Robertson pupil is always smaller (Adie) It is commoner in women than in men

Paralyses of the Extrinsic Ocular Muscles are common in tabes, occurring in about 20 per cent of the cases The order of frequency of the nerves affected is IIIrd (20 per cent) VIth (13 per cent) IVth (3 per cent), external or total ophthalmoplegia (2 per cent) It is characteristic of tabetic paralyses that they are partial, *i e*, not involving the whole nerve, incomplete, *i e*, pareses rather than paralyses, variable and transitory The affection of the IIIrd nerve is so common that it is always suggestive of a tabetic or syphilitic lesion Total IIIrd nerve paralysis is rare in tabes, and isolated ptosis is very common (4 per cent) The pareses of the ocular muscles nearly always occur in the pre ataxic stage when they occur at a later stage they are more likely to be permanent They generally clear up rapidly, but show a marked tendency to recur They may be due to nuclear lesions, or to involvement of the proprioceptive fibres (Sherrington) Considering that tabes is essentially a disease of afferent tracts it is curious that the Vth nerve almost always escapes Nystagmus is rare, but the paresed muscles often give rise to jerky movements of the eyes which may be mistaken for nystagmoid jerks Paralyses of associated movements *e g*, conjugate deviations are very rare

In Combined Sclerosis, in which both the posterior and the

lateral columns of the cord are affected, all the ocular mani festations characteristic of tabes may occur, these are probably atypical cases of tabes. In subacute combined sclerosis, such as is specially associated with anæmia and cachexia, ocular symptoms are rare.

In Hereditary Ataxy (Syn.—Friedreich's Disease) optic atrophy and paralyses of the ocular muscles are very rare. Nystagmoid jerkings of the eyes, very similar to those occurring in disseminated sclerosis, are very common, but the visual symptoms characteristic of the latter disease are absent. The movements are probably due to the same lack of co ordination which causes the other ataxic signs of the disease, they occur on voluntary movement and are not usually present in passive fixation.

Congenital Spastic Paralysis (Syn.—Little's Disease) is probably due to subdural hæmorrhage resulting from difficult labour. Of these cases 30—40 per cent have concomitant convergent squint.

Myelitis. A considerable number of cases of optic neuritis associated with myelitis have been described. The visual defect usually precedes the signs of myelitis. Its onset is sudden, but one eye may be affected a day or so before the other. Complete amaurosis generally supervenes rapidly. In some cases there is a central scotoma in the early stages, and there may be pain on moving the eyes, pointing to a retro bulbar neuritis. There is usually only slight neuritis, but considerable swelling of the disc has been seen. In cases which recover the blindness passes off and good vision is restored. Since the site of the myelitis may be lumbar or dorsal and as anatomical continuity of the inflammatory process from the cord to the optic nerves cannot be demonstrated, it is almost certain that the ocular affection is due to toxins circulating in the blood. There are no signs of general meningitis, and other cranial nerves escape.

During the amaurotic stage the pupils are dilated and immobile. In cases of cervical and upper dorsal myelitis without optic neuritis the pupils are often unequal, owing to implication of the dilatator tracts. In these cases the pupils still react to light.

Disseminated Sclerosis (Syn.—Multiple or Insular Sclerosis). Lesions in disseminated sclerosis often occur in the visual paths (50 per cent of cases) (Fig 331). Unlike the lesions of tabes, the medullary sheaths of the nerve fibres are specially attacked, the axis cylinders remaining relatively little affected.

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Hence, during the acute stage, defects in conductivity are specially prominent, considerable variations succeed each other, and high degrees of functional restoration are possible. The optic nerves are most frequently attacked, with all the clinical signs of a typical retrobulbar neuritis but patches of degeneration in the chiasma optic tracts, or optic radiations may cause characteristic hemianopic changes in the fields. In

Fig 331 —Disseminated Sclerosis. From a specimen by Gordon Holmes photographed by Coats. Chiasma, optic nerves and tracts Stained by Weigert Pal method the light areas being patches of degeneration

ordinary cases there is central scotoma with a full field. The scotomata are generally only relative: they are therefore easily overlooked and can be demonstrated only by the use of small coloured objects. Concentric contraction of the field and irregular peripheral defects, sometimes only for colours, also occur, and these show variations from time to time. Hemianopic fields are rarer than might be expected.

The ophthalmoscopic changes show very little direct relationship to the visual defects. There may be complete

blindness with normal fundi, and signs of optic atrophy may coincide with good vision   Owing to the relative escape of the axis cylinders much less peripheral degeneration occurs than might be anticipated   Owing to the recovery of conductivity in the fibres, vision generally improves materially, but repeated relapses are not uncommon   The visual symptoms may precede other signs by several years   Permanent complete blindness scarcely ever occurs   Uhthoff found marked optic atrophy in 3 per cent, incomplete atrophy in 19 per cent, temporal pallor of the disc in 18 per cent and optic neuritis in 5 per cent of cases   The optic nerves are affected, therefore, much more commonly than in tabes, more often indeed than in any other disease of the nervous system except cerebral tumour

The visual symptoms of disseminated sclerosis may be mistaken for those of toxic amblyopia, retrobulbar neuritis, tabes, or hysteria   The diagnosis from the two former is the most difficult   In ordinary retrobulbar neuritis the central scotoma is usually absolute , in disseminated sclerosis relative   In toxic amblyopia the scotoma is practically always bilateral , in disseminated sclerosis it is unilateral in about half the cases   In retrobulbar neuritis it is nearly always unilateral, and to these cases the early stages of disease of the pituitary gland must be added   Some cases can only be definitely diagnosed by the history and by the development of other pathognomonic signs   With regard to tabes central scotoma is rare and on the other hand symmetrical concentric contraction of the field is rare in disseminated sclerosis   Moreover, the failure of vision is steadily progressive in tabes, and is bilateral , in disseminated sclerosis it is unilateral and very variable   The diagnosis from hysteria may be difficult, but the regular concentric contraction of the field so often found in this condition scarcely ever occurs in disseminated sclerosis and sudden or half-sustained contraction of the pupil to light (*vide* p 395) is pathognomonic of organic disease

Nystagmus occurs in multiple sclerosis (12 per cent of cases), *but nystagmoid jerks are much commoner (50 per cent of cases)*   True nystagmus is a very important diagnostic sign, as it is rare in other acquired diseases of the central nervous system   nystagmoid jerks are of much less diagnostic significance   Both are probably due to central changes, and the latter show some analogy to the intention tremor so characteristic of disseminated sclerosis

Miosis is fairly common in this disease, and to a less degree

inequality of pupils   Other abnormal pupil reactions are
rare

Paralyses of extrinsic ocular muscles are much less common
than in tabes, and although resembling those in their partial
and transitory nature differ from them in that paralyses of
associated movements are not uncommon   Thus paresis of
convergence, with retained action of the recti in lateral move
ments, frequently occurs   Paralysis of lateral conjugate
movements is commoner than that of upward and downward
movements   These are obviously due to nuclear or supra-
nuclear lesions   Of individual nerves the VIth is more often
affected than the IIIrd, and total IIIrd nerve paralysis is
never seen (cf Tabes)   Partial ophthalmoplegia externa, with
intact intrinsic muscles also occurs   whereas ophthalmoplegia
interna is unknown

Syringomyelia is due to dilatation of the central canal of the
cord and excavation of the central grey matter   Since the
dorsal and lower cervical regions are often affected inequality
of the pupils is the most characteristic ocular sign   It is due
to implication of the dilatator tract , the pupil on the affected
side is small and reacts to light, but does not dilate after
instillation of cocaine (*vide* p 63)   Other signs of paralysis
of the cervical sympathetic may be present, such as slight
ptosis   retraction of the globe, &c   Paralysis of the Vth
nerve is also not uncommon, and the VIth nerve may be
affected but very rarely the IVth or IIIrd   Syringomyelia,
however, is sometimes complicated with tabes, and in these
cases all the ocular manifestations of tabes may occur   The
patients are often hysterical   a fact which accounts for the
frequency of concentric contraction of the fields of vision

Myasthenia Gravis   This disease shows some resemblance
to chronic progressive bulbar paralysis, but differs from it,
inter alia, in the fact that the ocular muscles are almost
invariably affected   Most of the patients are young, and have
difficulty in articulation, swallowing, and mastication   There
is nearly always ptosis and paresis of the orbiculares palpe
brarum   The muscles of the extremities and trunk become
affected, or the disease may start in them   Dyspnœa is
common, especially on exertion   A striking feature is the
absence of muscular atrophy   The muscles do not give the
reaction of degeneration, but show the " myasthenic reaction,"
i e , they respond worse and worse to repeated faradic stimuli
The most characteristic feature is the rapid fatigue of the
muscles   The symptoms are least marked in the morning,

e g, the ptosis is much worse in the evening   Reading is only possible for a few minutes owing to failure of convergence and lateral movements of the eyes   Only a few mouthfuls of food can be masticated owing to fatigue of the muscles   The same applies to other voluntary muscles, which are similarly rapidly tired out by electrical stimulation   The muscles recover rapidly in the early stages of the disease after a short rest   The symptoms fluctuate from day to day, and may remain in abeyance for considerable periods   Sensory and cerebral symptoms are absent, and the reflexes are normal   Many cases die of failure of respiration, though the course of the disease is usually long   No pathological changes are found in the nervous system, but groups of lymphocytes ("lymphorrhages") have been found in the muscles, and the thymus is sometimes enlarged

The ptosis is nearly always bilateral and is increased by prolonged fixation or attempts to look upwards   Effective compensation by over action of the frontales is impossible   Ophthalmoplegia externa, partial or complete, occurs in 50 per cent of the cases   The intrinsic muscles are not affected   *Nystagmoid jerks are not uncommon*

Remarkable temporary improvement in the action of the muscles is obtained by injections of prostigmin

Myotonia Atrophica is a familial, hereditary disease, characterised by weakness of muscles (facial, vasti, &c), and slow relaxation after contraction   The patients frequently develop cataract at an early age—20 to 40—and the cataracts may be the first manifestation of the disease

Ophthalmoplegia   Ophthalmoplegia is a somewhat indefinite term applied to widespread paralysis of the muscles of the eye which is thought to be due to nuclear lesions and forms the most prominent feature of the cases   Nuclear paralyses often cause defects of convergence, conjugate deviation of the eyes, and so on, when these are isolated signs the term ophthalmoplegia should not be applied to them   In typical ophthalmoplegia both eyes are affected, though all the muscles need not necessarily be simultaneously paralysed   In ophthalmoplegia totalis all the muscles, extrinsic and intrinsic, are affected   in ophthalmoplegia externa, many or all of the extrinsic muscles,   in ophthalmoplegia interna, the intrinsic muscles   Ophthalmoplegia may be acute or subacute and chronic

Acute or subacute ophthalmoplegia is usually due to poisons

or infection, and is relatively rare   The chief poisons are alcohol, lead, and ptomaines , the chief infections, diphtheria and influenza   In acute alcoholism the onset is sudden and accompanied by cerebral symptoms—headache, delirium, coma, &c   Bilateral ophthalmoplegia externa comes on suddenly or rapidly, with or without ptosis, and is often followed by facial and bulbar paralysis, with difficulty in speech and swallowing   The intrinsic muscles usually escape The condition is probably due to acute hæmorrhagic superior polioencephalitis (Wernicke)   In lead poisoning the onset is less acute and the intrinsic muscles are more often involved In ptomaine poisoning, due to bad food, mussels, &c , the essential feature is bilateral ophthalmoplegia interna, with or without ptosis, but total ophthalmoplegia also occurs   In diphtheria isolated ocular palsies are common, but ophthalmoplegia externa is rare   The pupil often escapes, the ciliary muscle never   In influenza the ophthalmoplegia resembles that of diphtheria—extrinsic muscles and ciliary muscle, the pupil escaping, but the pupil has been known to be affected without the ciliary muscle   The prognosis in alcoholism is bad   other cases usually recover

Chronic ophthalmoplegia is usually progressive   It commences with ptosis or diplopia   In the course of months or years the paralysis spreads to all the ocular muscles of both sides, except that the intrinsic muscles often escape, and not infrequently the levatores palpebrarum also   These cases of isolated chronic ophthalmoplegia are rare, but the condition is often a precursor or symptom of tabes or general paralysis of the insane, rarely of disseminated sclerosis, &c   It is a very early sign of tabes, and may become associated later with bulbar symptoms   The Argyll Robertson pupil or ophthalmoplegia interna is often present

Ophthalmoplegia also occurs as a congenital disease or may be acquired early in life as an hereditary familial disease In these cases there is usually only partial ophthalmoplegia externa, and the condition is not complicated by other nervous disease such as tabes or bulbar paralysis, thus differing from the adult acquired form

Diseases of the Pons   The ocular symptoms are of great localising value in diseases of the pons   Of these, tumours are by far the most common, hæmorrhages, thromboses, softening, and abscess being relatively rare

Tumours   By far the commonest tumours of the pons are tubercle and glioma, the former being about twice as common

as the latter   Both occur most frequently in childhood   Papilloedema or papillitis occurs in about half the cases, and is accompanied by the usual visual symptoms   The most characteristic signs of pontine tumours are due to implication of the motor nuclei and pyramidal tracts (*vide* Figs 295—301)   The VIth nucleus is usually implicated and causes loss of conjugate movement of the eyes to the same side (*vide* p 543) with retention of convergence   at the onset the external rectus only may be paralysed   Owing to the immediate vicinity of the pyramidal tract it is also generally involved, and as the fibres are affected before they decussate in the medulla oblongata there is contra lateral hemiplegia   The intimate relationship of the VIIth nucleus and its afferent fibres to the VIth nucleus has already been mentioned   Hence, facial paralysis combined with loss of conjugate deviation of the eyes to the same side suggests a pontine lesion   Similarly facial paralysis with contra lateral hemiplegia (Millard Gubler's syndrome) has the same significance   If the lesion is situated high up in the pons the pyramidal tract is caught before the fibres to the facial nucleus have crossed   Hence in these cases there is facial paralysis combined with hemiplegia on the same side   The facial paralysis is then usually of the cerebral type, in which the orbicularis palpebrarum, which is said to be innervated from the IIIrd nucleus, escapes   Not infrequently the Vth nerve is partially paralysed causing, for example paralysis of the Vth, nuclear VIth VIIth, and sometimes VIIIth nerves, with crossed hemiplegia   It is astonishing how large pontine tumours can become without causing death, the nervous structures being pushed aside, especially in the relatively slow development of tuberculous masses   Extension of the disease may lead to IIIrd nerve paralysis, practically never IVth, the fibres of which are protected by the dorsal position of their decussation   If ptosis is the only sign of involvement of the IIIrd nerve its localising value is slight , it may be a mere pressure symptom or a cerebral ptosis   Occasionally the opposite pyramidal tract is involved, with bilateral hemiplegia   Owing to the combination of facial paralysis the cases in which the trigeminal is involved are more likely to cause neuroparalytic keratitis (*q v*) than are other lesions of the Vth nuclei or intra medullary fibres   Miosis is not uncommon in tumours of the pons, but the pupillary signs are of little diagnostic value , nystagmus is a sign of involvement of the cerebellum

In *hæmorrhages* and *thromboses* in the pons the same motor

signs are manifest, and are usually of rapid or sudden onset
There are no ophthalmoscopic changes The pupils are usually
very small in the early stages of pontine hæmorrhage, a point
of considerable diagnostic significance in an unconscious
patient

Tumours of the Auditory Nerve *(Syn —Extra-cerebellar
Tumours)*   The peculiar slow growing neuro fibromatous or
endotheliomatous tumours of the recessus acustico-cerebellaris,
usually attached to the VIIIth nerve, give rise to a fairly
characteristic syndrome with ocular signs   Early deafness
on one side is associated with cerebellar symptoms, among
which nystagmus is common   The VIth nerve is usually
involved, generally with paralysis of the external rectus only,
rarely with paralysis of conjugate deviation   As might be
expected, there is very often facial paralysis of the peripheral
type, i e , total, including the orbicularis palpebrarum   The
Vth nerve is implicated in about a quarter of the cases, but
neuroparalytic keratitis is uncommon   In nearly all the cases
there is pronounced papillœdema

Diseases of the Cerebral Peduncle (Figs 56, 296) —The most
characteristic sign of disease of the cerebral peduncle is a
combination of paralysis of the IIIrd nerve with contra lateral
hemiplegia, the latter including the face and tongue (Weber's
syndrome)   The facial paralysis is naturally of the cerebral
type, in which the orbicularis palpebrarum escapes, since it
is due to a pyramidal tract lesion   If the red nucleus (Fig 296)
is involved tremor and jerky movements occur in the contra
lateral side of the body   this condition combined with ipsi
lateral IIIrd nerve paralysis forms Benedikt's syndrome
Motor and sensory hemiplegia, contra lateral to the lesion,
without IIIrd nerve paralysis, is less common than Weber's
syndrome, and IIIrd nerve paralysis alone is rare   In the
usual syndrome the whole IIIrd nerve is involved, the intrinsic
muscles rarely escaping   when it occurs it is due to an intra
peduncular fascicular lesion   Both oculomotor nerves are
sometimes affected   As might be expected (Figs 56, 296),
implication of the external geniculate body or optic tract may
occur, with development of homonymous hemianopia. Since
the commonest lesion in this region is solitary tubercle,
papillœdema occurs in about 10 per cent of the cases   The
most frequent other causes, omitting basal gummatous
meningitis, which may affect the peduncle secondarily, are
softening and hæmorrhage

Diseases of the Corpora Quadrigemina and Pineal Gland

Though there can be no doubt that visual functions are located in the optic lobes of lower animals these functions are submerged in their later representatives, the anterior colliculi There is no good evidence that lesions of the corpora quadrigemina cause any direct impairment of vision in man The anatomical relations of the posterior colliculi point to association with hearing, and lesions of the corpora quadrigemina are frequently accompanied by impairment of hearing, which may, however, be due to pressure on the auditory paths The commonest lesion of these bodies is solitary tubercle, which acts like an intracranial tumour, and glioma Tumours of the pineal gland are generally gliomata, they press upon the colliculi and cause similar though less pronounced symptoms

As might be expected, tumours in this region very frequently cause papilloedema from pressure on the aqueduct of Sylvius, and therewith deterioration of vision The sign of greatest localising value is loss of upward and downward movement of both eyes Sometimes only upward movement is lost, never downward alone The other movements of the eyes are relatively good It is noteworthy, in opposition to experimental data, that impairment of conjugate lateral movements of the eyes is almost unknown in these lesions In more than half the cases there is paresis of both IIIrd nerves Less often only one oculomotor nerve is affected Extension of the pressure effects may lead to bilateral IVth nerve paralysis or ophthalmoplegia externa, but the VIth nerve, as might be expected, is seldom directly affected Pupillary changes are common, owing to implication of the IIIrd nerves or papilloedema Experimental and clinical evidence alike tend to show that, in spite of the intimate relationship of the afferent pupillary paths with the superior colliculi, lesions of these bodies cause no direct permanent changes in the pupillary reactions The facial nerve is paralysed in about a quarter of the cases the paralysis is of the cerebral type It is occasionally accompanied by ipsilateral hemiplegia These are distant signs due to pressure *Nystagmus occurs more frequently than with other cerebral tumours,* but is usually associated with defects of co-ordination and other signs of implication of the cerebellum These cases are always difficult to diagnose from cerebellar lesions, and the order of onset of the symptoms is important If the ocular movements are affected first, and especially if upward and downward movements are lost, the lesion is probably quadrigeminal, if the cerebellar ataxy precedes the impair

ment of ocular movements the lesion is probably in the cerebellum (Bruns)

General Paralysis of the Insane *(Syns — Progressive Paralysis, Paralytic Dementia)* Like tabes, this is a para syphilitic disease It is often accompanied by tabetic signs and symptoms which are due to lesions of the posterior tracts of the cord identical with those in tabes (tabo paralysis) The ocular symptoms are most common and unequivocal in these cases, and are to be attributed to the same causes

The *pupillary* changes are most characteristic In the early stages inequality of the pupils is most common It should be quite definite to be of diagnostic value, for slight inequality is not very infrequent in normal people It is often accompanied by slight deformation in the shape of the pupil and irregularity of the pupillary margin The same remark applies to these changes The pathological nature of the pupillary changes is put beyond doubt when there is the typical Argyll Robertson reaction It occurs in nearly half the cases and is therefore an important sign, but less constant than in tabes In about 5 per cent of the cases the reactions both to light and convergence are lost, a condition which is rare in tabes and especially frequent in the juvenile form of general paralysis The sensory reaction, *i e*, dilatation of the pupil on painful stimulation of the skin, is very often lost with the light reaction The Argyll Robertson pupil is rare in cases in which the knee jerks are retained Spinal miosis is commoner in tabes, unequal pupils in general paralysis Ophthalmoplegia interna is rarer in general paralysis

Primary optic atrophy occurs in about 8 per cent of cases (Uhthoff) It shows exactly the same type and course as in tabes but is more frequent in the latter disease Like the pupillary signs it may precede the onset of the typical cerebral symptoms by a considerable period, especially in those cases which commence with tabetic symptoms

Paralyses of the extrinsic ocular muscles occur about half as frequently as in tabes, and have exactly the same charac teristics, the IIIrd nerve being most frequently involved

Cerebral Syphilis is the term usually applied to relatively early direct syphilitic disease of the brain and meninges Its manifestations differ very materially from those of the para syphilitic diseases and the ocular symptoms are of special diagnostic importance Cerebral syphilis is due essentially to gummatous inflammation of the meninges and the walls of the cerebral blood vessels

The chief form of brain syphilis is basal gummatous menin gitis. It usually arises from the subarachnoid tissue in the region of the chiasma and spreads thence over the base of the brain. The optic nerves, chiasma, and tracts are generally involved. Papillitis, papilloedema, or post-neuritic atrophy are frequently found (about 13 per cent each) and are usually bilateral. Visual defects are very common and consist of amblyopia, not infrequently amaurosis and defects in the fields of vision. Of the latter many cases show homonymous hemianopia from affection of one tract; fewer cases temporal hemianopia. Central scotoma and other signs of retrobulbar neuritis also occur. The IIIrd nerve is paralysed in a third of the cases, less commonly the Vth and VIth, and least frequently the IVth. The IIIrd and VIth are often affected on both sides. The trigeminal paralysis is always unilateral and often causes neuroparalytic keratitis. Pupillary changes occur, dependent upon the IIIrd nerve lesions. In many cases the process is limited to a small area oculomotor paralysis, or an affection of the visual path being the only signs except headache. A very characteristic feature of basal gummatous meningitis is the inconstancy and variability of the symptoms, temporary and recurrent visual and oculomotor disturbances being very common.

Isolated gummata may give rise to the signs of cerebral tumour, complicated by the fact that they are often multiple. Syphilitic disease of the cerebral vessels is responsible for a large proportion of cases of thrombosis, hæmorrhage, softening &c.

Intracranial Tumours The commonest ocular manifestation of intracranial tumours is papilloedema or papillitis. The latter term is used in this connection for the slight degrees of swelling of the disc, and does not necessarily imply a true inflammatory process.

Analysis of 200 cases of intracranial tumour treated at the National Hospital, Queen Square, shows the following results (Paton) :—

(1) Precentral tumours are nearly always associated with neuritis fairly severe in character. (2) Postcentral tumours are nearly always associated with papilloedema as a rule moderate, and often of very short duration. (3) Temporosphenoidal tumours are always associated with papilloedema of about the same degree of severity as in frontal tumours. (4) Of subcortical tumours about one-half develop papilloedema —as a rule, moderate in degree—and as in the case of parietal

tumours, frequently of short duration. (5) Optic thalamus and mid brain tumours are almost invariably associated with papilloedema of very great severity (6) Cerebellar tumours are constantly accompanied by papilloedema of a grave character (7) Extra-cerebellar tumours as a rule, develop papilloedema of a grave character (8) Of pontine tumours, only about one half develop papilloedema, and then only when neighbouring parts of the brain especially the cerebellum, have become involved the papilloedema when it does develop is usually very severe (9) Ventricular tumours develop a moderate papilloedema

There are two regions of the brain, the pons and the central white matter of the cerebral hemispheres, in which tumours frequently develop without causing papilloedema Some cases of meningeal tumours in which the brain substance escapes do not develop papilloedema When a tumour directly or in directly exercises pressure on the chiasma or optic nerves atrophy may occur without preceding papilloedema (*vide* pp 389, 393) In these cases loss of vision may precede ophthalmoscopic signs, and may first be manifest as a uni lateral central scotoma (*vide* pp 393 396 408)

Homonymous hemianopia is due in about half the cases in which this symptom is present to tumours of the occipital lobes About 20 per cent are due to involvement of one tract, either direct or as a pressure symptom Relatively few are due to involvement of the internal capsule or ex ternal geniculate body Heteronymous hemianopia is much rarer and is due to pressure on the chiasma and tracts by tumours of the pituitary body or distension of the third ventricle

Paralysis of ocular muscles is relatively rare and nearly always a distant pressure symptom One or both VIth nerves are often affected, the IIIrd nerve rarely, the IVth practically never Conjugate lateral deviation of the eyes which is com mon in cerebral hæmorrhage and to a less extent in cerebral softening is rare with tumours of the cerebrum It is more frequent with cerebellar tumours Paralyses as true localising symptoms may of course occur with tumours of the crus, pons, &c To this category belongs trigeminal paralysis with or without neuroparalytic keratitis it is rare with cerebral commoner with cerebellar tumours

Intracranial Abscess Cerebral abscess occurs about three times as often as cerebellar The majority of cerebral abscesses are due to middle ear disease and affect the temporal lobes Others are due to traumatism and generally affect the parietal

lobes   Rarer causes are metastatic infection, usually derived from the lungs, frontal sinus empyema, and orbital cellulitis   A still greater proportion of cerebellar abscesses is due to otitis media

Nearly half the cases have either papilloedema or papillitis   it is not infrequently on the side of the abscess only, and in bilateral cases the swelling is generally greater on this side   This sign has therefore greater localising value in intracranial abscess than in tumour   Papilloedema persists longer after operation for abscess than for tumour, or may even only then commence   As might be expected optic atrophy is rare during the acute stage   its presence militates against the diagnosis of abscess   Ophthalmoscopic changes are rarer with extradural abscesses

Homonymous hemianopia indicates a lesion of the occipital lobe, which is rarely due to otitis

Partial unilateral IIIrd nerve paralysis is *fairly common*, and the combination of unilateral ptosis and mydriasis has almost pathognomonic significance of ipsilateral cerebral or cerebellar abscess   Partial IIIrd nerve paralysis with contralateral hemiplegia points to abscess of the temporal lobe with pressure on the IIIrd nerve and internal capsule, or more rarely to implication of the cerebral peduncle   Paralysis of the VIth nerve is not common, but is found rather oftener in cerebellar than cerebral abscess   it is generally ipsilateral, but has little localising value   Paralysis of the Vth nerve is rare   Nystagmus is very common with cerebellar abscess, but rare with cerebral   In otitic cases it may be due to disease of the labyrinth

Intracranial Aneurysm and Sub arachnoid Hæmorrhage   Intracranial aneurysms are not very rare, and may rupture spontaneously or after head injury into the subarachnoid space   The rupture is usually accompanied by sudden very acute headache, vomiting and dizziness   Coma may rapidly supervene   Meningeal irritation is shown by stiffness of the neck and often by Kernig's sign   The ocular signs are ocular palsies, especially of the IIIrd or VIth nerve, moderate papilloedema, retinal hæmorrhages, usually multiple in the neighbourhood of the disc, rather large, and often sub hyaloid, vitreous hæmorrhage, proptosis, and defects in the visual fields   There is always blood in the cerebrospinal fluid, as shown by lumbar puncture

Acrocephaly (*Syn—Oxycephaly*) is due to precocious union of certain cranial sutures   occipito parietal and fronto parietal

(*turricephaly tower skull*), sagittal (*scaphocephaly*) Asynchronous fusion of bones leads to a lop sided skull (*plagiocephaly*) The great wing of the sphenoid is displaced so that the orbit becomes shallow, causing more or less proptosis In the early stages there is papilloedema but more commonly only the later stage of post neuritic optic atrophy is seen The amount of atrophy varies in degree The papilloedema is probably due to increased intra cranial pressure owing to continued growth of the brain in a restricted space Divergent strabismus, horizontal nystagmus and mental deficiency are common Most of the patients are males Acrocephaly may be associated with syndactylism (Apert's disease)

Encephalitis Ocular palsies usually usher in an attack of *encephalitis lethargica* Ptosis is the commonest feature, and other branches of the IIIrd nerve are specially involved The muscles are usually only partially paralysed, and generally recover Diplopia is an early symptom, and nystagmus may be present Papilloedema is rare and the pupils are usually normal The general symptoms are lethargy, with great muscular debility, and other signs of an acute general infection The disease is often followed by Parkinsonian tremor (paralysis agitans), and in the later stages spasmodic conjugate deviation of the eyes occurs (oculogyric crises) accompanied by synergic movements of the head and neck Oculogyric crises are relieved by benzedrine (up to 30 mm a day)

Acute *polioencephalitis* accounts for not infrequent cases of paralytic squint following a febrile attack in young children The VIth nerve is most often involved

Meningitis In *tuberculous meningitis* a moderate degree of papilloedema is common (about 25 per cent) and is generally bilateral Papilloedema occasionally occurs and indicates the combination of solitary with miliary tubercle Tubercle in the choroid is frequent and of great diagnostic importance A review of the literature tends to show that it is less common in tuberculous meningitis than in generalised miliary tubercle, but my own observations lead me to think that it is much commoner than is generally thought It is often found only a day or two before death There are often partial ocular pareses usually of the IIIrd nerve, especially in the form of ptosis Bilateral IIIrd paralysis is almost unknown, a point of distinction from syphilitic basal meningitis Unilateral partial VIth nerve paralysis also occurs Not infrequently

there is a kinetic (not paralytic) conjugate deviation of the
eyes and head to one side

In epidemic cerebro spinal meningitis papillitis is frequently
present, never papilloedema , it is due to a descending infective
neuritis   In the early stages there is often kinetic strabismus
or conjugate lateral deviation of the eyes   A characteristic
sign is the widely open palpebral aperture, often associated
with very infrequent blinking   Paralysis of the IIIrd nerve,
usually unilateral, is commoner than that of the IIIrd though
divergent strabismus due to the latter cause has been fre
quently noted   Total IIIrd nerve paralysis is rare (cf Gum
matous Basal Meningitis)   The pupils vary much, usually
showing miosis in the early stages   mydriasis when coma sets
in   loss of reaction to light is relatively rare   Conjunctivitis
and keratitis sometimes occur, and many cases of metastatic
endophthalmitis (q v) in children are due to the Weichselbaum
meningococcus, though it is a relatively rare complication of
the disease

Still and others have shown that the sporadic acute basal
meningitis of children is due to the meningococcus   A pecu
liarity of this disease which I have frequently seen at Great
Ormond Street Children's Hospital is complete amaurosis
with normal fundi and normal pupil reactions, pointing to the
action of toxins on the higher visual centres   The blindness
may persist for many weeks after subsidence of other symp
toms, and sight may be completely restored   Chronic basal
meningitis sometimes shows the same feature, but in these
cases optic neuritis and post neuritic atrophy may occur from
secondary hydrocephalus and pressure of the distended third
ventricle upon the chiasma and tracts

Purulent meningitis occurs occasionally in typhoid, and
more rarely in pneumonia, influenza, scarlet fever, measles,
and septicaemia   In typhoid the diagnosis is difficult, but the
presence of papillitis and ocular paralyses points in this
direction   Metastatic purulent meningitis, with papillitis or
retrobulbar neuritis occurs in children from obscure causes
Middle ear disease is a not uncommon cause of purulent menin
gitis   In this condition papillitis or papilloedema is usually
due to complications, such as sinus thrombosis or cerebral
abscess   When ocular paralysis occurs, the VIth nerve is
usually affected, rarely the IIIrd (cf Intracranial Abscess).
The facial nerve is most frequently involved, the paralysis
often causing lagophthalmia   Conjugate deviation of the eyes
is not uncommon   Metastatic endophthalmitis is rarer than in

epidemic cerebro-spinal meningitis The diagnosis of otogenous meningitis from tuberculous may be difficult or impossible

Hydrocephalus   In the congenital and the early acquired hydrocephalus of infancy optic atrophy is not infrequently found Papilloedema occurs only rarely in spite of the increased intracranial pressure   This fact is doubtless due to the relief of pressure by the enlargement of the skull and the resiliency of the fontanelles and gaping sutures, as well as to the very gradual development   The eyeballs usually deviate downwards and upward movements are much restricted   This is sometimes due to bulging of the thin orbital plate of the frontal bone which may be even absorbed   Not infrequently there is considerable proptosis

The acquired hydrocephalus of later life, after the fontanelles and sutures have closed, is always rather a doubtful inference than a precise diagnosis   The cardinal signs of increased intracranial pressure—headache, vomiting and papilloedema—are present, and to these is often added ataxia of the cerebellar type   The cases are often diagnosed as intracranial tumours, in which localising signs are not infrequently absent or masked   Bitemporal hemianopia may give a clue to the true ætiology, being due to pressure on the chiasma and tracts by the bulging floor of the third ventricle   In some cases there is evidence of previous meningitis but the most characteristic feature is often the variability of the symptoms   Remissions and intermissions of long duration occur, and recovery or arrest of the condition is not uncommon, often, however, with defective vision due to post-neuritic atrophy

Fractures of the base of the Skull   Unilateral facial paralysis is the commonest cranial nerve lesion in fractures of the base of the skull (22 per cent of cases)   the VIth (4 per cent) IIIrd (2 per cent), Vth (1 6 per cent) and IVth (I per cent) follow in order of frequency   Fractures of the base from falls upon the head, &c , very often pass through the optic foramen and involve the roof of the orbit   occasionally both optic foramina are broken   Owing to the intimate union between the dura mater and periosteum the optic nerve is frequently injured   It may be torn through, lacerated by splinters of bone, or compressed by hæmorrhage into the sheath   If the nerve is completely severed there is blindness with a normal fundus in the early stages   In two to four weeks signs of primary optic atrophy appear and progress to total atrophy   Papilloedema indicates hæmorrhage into the nerve sheath and may occur from basal hæmorrhage without

fracture of the optic foramen Hæmorrhage into the sheath or nerve may cause concentric contraction of the field of vision, or quadrant and other sectorial defects central scotoma appears to be rare Most cases with rapidly developing papillœdema die Pigmentation in and around the disc may follow hæmorrhage into the sheath The pupil reactions vary and are not pathognomonic, but there is usually mydriasis on the side of the lesion

Statistics The statistics on this page (in percentages), derived from Uhthoff's very extensive investigations of the literature and of cases in the Breslau clinic, give some idea of the frequency of

	Pap Ilœdema	Papillitis	Optic Atrophy	Homonymous Hemianopia	Bitemporal Hemianopia	III Paralysis	IV Paralysis	VI Paralysis	V Paralysis	Conjugate Deviation of the Eyes	Nystagmus
Cerebral Tumour	53	18	8	17	1	14	0	11	6	3	4
Cerebellar Tumour	63	24	11	—	—	5	2	18	12	1 5	25
Cerebral Abscess	23	21	0 3	9	—	19	1 6	10	4	6	4
Cerebellar Abscess	23	22	—	—	—	14	—	12	4	6	42
Cerebral Syphilis	14	12	14	11	6	34	5	16	14	1	8
Cerebral Hæmorrhage	11	6 5	1	29	—	9	—	8 4	1	28	10
Cerebral Softening	1 4	2	0 8	40	—	2 4	—	0 3	2	12	1 6
Tuberculous Meningitis	5	29	1	—	—	18	1	12	5	8	10
Internal Hydrocephalus	23	20	19	—	—	6	—	13	—	3	13
Pituitary Body Tumours	9 3 5		21	3	32	17 2 5		6	—	—	4
Fractures of the Base of the Skull	9		4	—	—	2	1	4	6	2 5	3

important physical signs in certain diseases of the nervous system already discussed Too much reliance must not be placed upon the percentages, culled as the cases are from very various sources

CHAPTER XXX

Ocular Manifestations of other Diseases

THE most important ocular manifestations of other diseases than those of the central nervous system have already been discussed incidentally, and it will suffice here merely to enumerate them

Infectious Diseases Mucopurulent conjunctivitis and corneal ulcers are the chief ocular complications of *measles* They are rare in *scarlet fever*, as is also albuminuric retinitis Corneal ulcers are common in *small pox* Vaccinia of the eyelids is not uncommon and may affect the cornea, usually secondarily, sometimes causing disciform keratitis *Diphtheria* sometimes attacks the conjunctiva, it may cause cycloplegia (*vide* p 536), and rarely paralysis of the external rectus *Erysipelas* may cause abscesses and gangrene of the lids orbital cellulitis and thrombosis of the orbital veins and cavernous sinus Optic neuritis occurs in *typhoid fever* Conjunctivitis and the herpetic types of keratitis are common in *influenza* which also causes iritis and optic neuritis

Diseases of the Respiratory Tract Conjunctival hæmorrhages are common in *whooping cough*, and retinal hæmorrhages may also occur Herpes corneæ occurs in *pneumonia*, but it is remarkable that hypopyon ulcer is rare Apical *phthisis* may cause irritation of the sympathetic fibres, leading to dilatation of the ipsilateral pupil

Diseases of the Circulatory System Pulsation of the retinal vessels, embolism and thrombosis of the central artery, arterio-sclerosis, and thrombosis of the central vein of the retina have already been sufficiently discussed Aneurysm at the root of the neck may cause dilatation of the pupil on the same side In congenital heart disease the retinal vessels are usually dark and greatly engorged, or the veins alone may be abnormally large, retinal hæmorrhages are not uncommon

Diseases of the Blood *Chlorosis* has often been held responsible for papillitis but it is extremely doubtful if the diagnosis is accurate Retinal hæmorrhages, sometimes accompanied by white spots of exudate, occur in the

anæmias of carcinoma, ankylostomiasis, &c , and are a prominent sign in *pernicious anæmia*, which really belongs to this group In this disease they are often of characteristic colour as in leukæmia (*vide* p 371) The ophthalmoscopic signs of *leukæmia* have already been described Hæmorrhages in and about the eyes are common in scurvy and purpura, rare in hæmophilia Great loss of blood leads to amblyopia or amaurosis and may be followed by bilateral optic atrophy (*vide* p 400 Severe ocular symptoms very rarely follow traumatic hæmorrhage, as in war injuries, but most commonly result from intestinal or uterine hæmorrhage Though both eyes are usually affected there is often an interval of days between them The discs are hazy at first, later becoming atrophic, with constricted vessels In some cases slight improvement of sight eventually occurs

Diseases of the Organs of Digestion Oral sepsis, especially pyorrhœa alveolaris is an undoubted cause of iridocyclitis (*vide* p 269), and probably causes choroiditis and other forms of sub acute or acute endophthalmitis Infective lesions in the mouth may spread by continuity, especially along the veins of the pterygoid plexus, setting up orbital cellulitis or thrombosis of the cavernous sinus Lamellar cataract is associated with hypoplasia of the enamel of certain teeth The lacrymal gland is not infrequently affected in *parotitis*, which may be associated with irido cyclitis (*uveo parotid inflammation*) (*vide* p 275) Symmetrical inflammation of the lacrymal and salivary glands is characteristic of *Mikulicz' disease* (*vide* p 648) Absorption of bacterial toxins from the intestinal canal is almost certainly a cause of iridocyclitis and other obscure inflammations of the uveal tract Night blindness is associated with some *diseases of the liver e g* cirrhosis, and jaundice causes yellow discoloration of the conjunctiva, but yellow vision (xanthopsia) is much less common than has been thought

Diseases of the Kidneys Albuminuric retinitis and uræmic amaurosis have already been discussed

Metabolic Diseases Ocular complications are common in *diabetes mellitus*, but bear little relation to the severity of the disease , they occur chiefly in long standing cases, the most frequent being diabetic cataract, retinitis intraocular hæmorrhages, and retrobulbar neuritis Œdema of the pigment epithelium on the back of the iris is often seen in microscopical specimens, but iritis is seldom met with Remarkable changes in the refraction of the eye, both in the direction of hyperme

tropia and myopia, not infrequently occur in diabetics, due to alterations in the refractive index of the cortex of the lens, probably brought about by osmotic changes (*vide* p 325) Paralyses of both extrinsic and intrinsic ocular muscles also occur *Gout* has been held responsible for deposits in the conjunctiva (concretions), conjunctivitis, marginal ulcers of the cornea, episcleritis, scleritis, iritis, and other conditions it is indirectly the cause of ocular lesions through the kidneys and vascular system *Rheumatism* is an indefinite entity Acute rheumatism is doubtless an infective disease it practically never gives rise to iritis but may cause embolism of the central artery of the retina indirectly by its effects on the cardiac valves It rarely causes optic neuritis Chronic rheumatism is also probably due to organisms or bacterial toxins, and is thus responsible for iritis, cyclitis, episcleritis, and retrobulbar neuritis Interstitial keratitis has been described in *myxœdema* over feeding with thyroid causes exophthalmos (*vide* p 674) cataract, and amblyopia

Diseases of the Generative Organs It can scarcely be doubted that the profound changes which the generative organs, especially in the female, undergo at puberty, in men struation parturition and the climacteric, are often associated with disorders of metabolism and other pathological conditions Of these the albuminuric retinitis of pregnancy is the most impeccable example among ocular complications Loss of vision, starting in retrobulbar neuritis and followed by papillœdema and peripapillary retinal hæmorrhage, occurs in severe cases of hyperemesis gravidarum, probably as part of the syndrome of Wernicke's encephalopathy It may be due to some vitamin deficiency, *e g*, B_1 Many other ocular complications have been described, *e g*, conjunctivitis asso ciated with the menses, but their relationship to diseases of the generative organs is obscure The diseases due to gonor rhœa and syphilis have been described elsewhere

CHAPTER XXXI

Diseases of the Lids

Anatomy The lids are covered anteriorly by skin and posteriorly by mucous membrane—conjunctiva tarsi , they end in a free edge about 3 mm broad—margo intermarginalis The substance of the lids consists of muscle, glands, blood
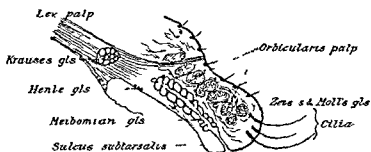
Fig 332 —Diagram of sagittal section of upper lid

vessels, and nerves, all bound together by connective tissue, which is particularly dense at the posterior part, where it forms a stiff plate—the tarsus (Fig 332)

The skin of the lids differs from that of the rest of the body merely in its thinness, its loose attachment, and the absence of fat in its corium It is covered with fine downy hair, which are provided with small sebaceous glands and there are also small sweat glands At the anterior border the hairs are specially differentiated to form a protection to the eyeball The cilia or eyelashes are strong, curved hairs, arranged in two or more closely set rows Their sebaceous follicles, like the cilia themselves, are specially differentiated and are called *Zeis's glands* Apart from being larger, they are identical with other sebaceous glands The sweat glands near

the edge is also unusually large and are known as *Moll's glands* They are situated immediately behind the hair follicles, and their ducts open into the ducts of Zeis's glands or into the hair follicles not direct on to the surface of the skin as elsewhere

The margin or free edge of the lid is the part between the anterior and posterior borders—the intermarginal strip or margo intermarginalis (Fig 333) It is covered with stratified epithelium, which forms a transition between the skin and the conjunctiva strip The anterior border is rounded , the posterior, which lies in contact with the globe, is sharp The capillarity induced by this sharp angle of contact is of import ance in the proper moistening of the surface of the eye Immediately anterior to the posterior border is a single row of minute orifices just visible to the naked eye These are the orifices of the ducts of the Meibomian glands Between this
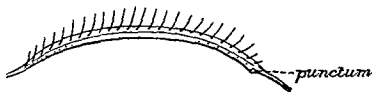
Fig 333 —Diagram of intermarginal strip

row of puncta and the anterior border is a fine grey line, which is important in operations in which the lid is split, as it indicates the position of the loose fibrous tissue between the orbicularis palpebrarum and the tarsus

The tarsus consists of dense fibrous tissue , it contains no cartilage cells so that the term tarsal cartilage is only justified in so far as it defines the consistence of the plate Imbedded in the tarsus are some enormously developed sebaceous glands, the *Meibomian glands* They consist of nearly straight tubes directed vertically, each opening by a single duct on the margin of the lid The tubes are closed at the upper end, and have numerous small cæcal appendages projecting from the sides, filled with fatty glandular epithelium The glands number from twenty to thirty, being rather fewer in the lower than in the upper lid

The large bundles of the orbicularis palpebrarum occupy the space between the tarsus and the skin The main central band of the levator palpebræ superioris is inserted into the upper border of the tarsus , an anterior slip passes between

the bundles of the orbicularis to be inserted into the skin of the middle of the lid, a posterior slip is inserted into the conjunctiva at the fornix. The inferior rectus and oblique muscles send fibrous strands forwards into the lower lid to be attached to the tarsus and palpebral ligament.

Besides these striped muscles there is a layer of unstriped muscle in each lid. These constitute the superior and inferior tarsal muscles of Muller. The fibres of the former arise among the striped fibres of the levator, pass down behind it, and are inserted into the upper border of the tarsus. The inferior lies below the inferior rectus and is inserted into the lower tarsus.

The arteries of the upper lid form two main arches, superior and inferior, the former lying between the upper border of the tarsus and the orbicularis, the latter in a similar position just above the hair follicles. In the lower lid there is usually only one arch near the free edge. There are two venous *plexuses in each lid* — *a post-tarsal passing into the ophthalmic* veins, and a pre tarsal opening into subcutaneous veins.

The sensory nerve supply is derived from the trigeminal. The third nerve supplies the levator palpebrae, the seventh the orbicularis, and the sympathetic Muller's muscles.

INFLAMMATION OF THE LIDS

Almost any of the inflammatory conditions which affect the *skin* in general may attack the lids. Erysipelas is dangerous in that it may spread to the orbit, leading to cellulitis and atrophy of the optic nerve, thrombosis of the cavernous sinus, or meningitis. Herpes ophthalmicus is often mistaken for erysipelas, its unilaterality, strict localisation to the course of branches of the ophthalmic nerve, and the characteristic formation of vesicles should prevent this mistake; permanent scarring remains after the attack. Eczema of the lids is common, especially associated with phlyctenular conjunctivitis (*q.v.*) in children, and with atropine irritation (*q.v.*). Dermatitis is not uncommonly caused by cosmetics; e.g., such as contain orris root and volatile oils and especially by applications for dyeing the lashes. Abscesses, boils, anthrax pustule, and ulcers of various kinds may affect the skin of the lids. Œdema of the lids may be inflammatory or passive. It is often associated with chemosis of the conjunctiva in severe conjunctivitis. Great œdema is often caused by bites of parasites, gnats, &c., and by styes, abscesses, and chancre of the lid. In unilateral œdema the condition of the lacrymal

sac and nasal duct should be investigated, it is often due to lacrymal abscess Situated above the internal palpebral ligament it suggests empyema of the frontal sinus, in the lower lid empyema of the antrum Localised œdema may be due to periostitis of the orbital margin In all cases of œdema the condition of the eyeball must be determined, with the assistance of Desmarres' retractors if necessary Œdema of the lids may be caused by serious purulent inflammation of the globe (panophthalmitis), of Tenon's capsule, by phlegmon of the orbit or thrombosis of the cavernous sinus Passive œdema may be due to nephritis, heart disease, &c, or it may be angioneurotic Chronic thickening of the lids, resembling œdema, but harder in consistency, may follow recurrent attacks of erysipelas—so-called *solid œdema*

Blepharitis is a chronic inflammation of the margins of the lids It may manifest itself as a simple hyperæmia, differing from that caused by weeping exposure to tobacco smoke, and so on in being more persistent The causes and treatment are the same as for the more severe forms of blepharitis True blepharitis occurs in two forms In *squamous blepharitis* small white scales like dandruff, accumulate among the lashes, the latter fall out readily, but are replaced without distortion If the scales are removed the underlying surface is found to be hyperæmic, but not ulcerated The condition is probably a seborrhœa

In *ulcerative blepharitis* yellow crusts glue the lashes together, on removing them small ulcers, which bleed easily, are seen around the bases of the lashes The lashes fall out or are easily pulled out, and often are not replaced, or grow in a distorted form, owing to injury to the follicles This blepharitis causes redness of the edges of the lids, itching, soreness, lacrymation and ' photophobia "

The sequelæ of the ulcerative form are serious If not treated energetically and with perseverance the disease is extremely chronic causing or being accompanied by chronic conjunctivitis Care must be taken to distinguish true blepharitis from matting together of the lids by conjunctival discharge, in the latter case removal of the crusts reveals quite normal lid margins The ulceration is liable to extend deeply, so that the hair follicles are destroyed Only a few small, scattered, distorted cilia are then found (*madarosis*)

When the ulcers heal the cicatricial tissue contracts Neighbouring hair follicles are drawn out of place, and a false direction is given to the remaining cilia, so that they may rub

against the cornea (*trichiasis*) Or the development of cicatricial tissue may be extreme, so that the edge of the lid becomes hypertrophied and droops in consequence of its weight (*tylosis*)

The lower lid is particularly liable to be displaced by prolonged ulcerative blepharitis The contraction of the scar tissue drags the conjunctiva over the margin , the posterior lip of the intermarginal strip instead of being acute angled, becomes rounded, so that its capillarity is impaired (*vide* p 616) Tears then tend to run over (*epiphora*), a condition which is accentuated if the punctum becomes everted, so that it ceases to lie in accurate contact with the bulbar conjunctiva (*vide* p 648) The continual wetting of the skin with tears leads to eczema, which is followed by contraction The condition is made worse by perpetually wiping the eyes, so that eventually *ectropion* is developed This causes still more epiphora, a vicious circle being set up

The causes of blepharitis are multitudinous The patients are usually children debilitated from living under poor hygienic conditions, or from disease, *e g* , anæmia, tubercle, syphilis, measles, &c The condition may follow chronic conjunctivitis, or be induced by the same causes, especially smoky atmosphere, heat (stokers cooks), late hours, &c It may result from a neglected diplobacillary blepharo conjunctivitis It is undoubtedly often associated with uncorrected errors of refraction, especially hypermetropia and astigmatism, which probably act by inducing reflex hyperæmia Occasionally parasites cause blepharitis, *e g* , blepharitis acarica, due to demodex folliculorum, and phthiriasis palpebrarum, due to the pediculus pubis, very rarely to pediculus capitis In the latter condition the cilia are covered with black nits, an appearance being produced which is easily recognised when once seen

Treatment The local treatment of blepharitis must be energetic in the ulcerative form The crusts must first be removed This is effected most easily by soap and water, followed by thorough bathing with hot borax or bicarbonate of soda lotion, 3 per cent The application softens the deposits, so that they can be picked or rubbed off with a pledget of cotton wool When the crusts have been entirely removed the surface is covered with an ointment of yellow oxide of mercury, ammoniated mercury, or ichthyol (5 per cent), which is gently well rubbed in for at least five minutes, so as to insinuate it into the hair follicles These procedures should be repeated

three times a day   In most cases, if the treatment is carried
out properly, there is a speedy cure   Unfortunately the treat-
ment is seldom carried out satisfactorily   It is useless merely
to smear ointment on the surface of the crusts   It must be
applied to the inflamed tissues and rubbed well into the lashes
The treatment should be continued for 2 or 3 weeks after
apparent cure as organisms lie hidden in the follicles and
the inflammation is likely to recur

In more severe cases, or when the above treatment is
improperly done protargol, 15 to 20 per cent   should be
rubbed into the margins of the lids with a stumpy camel's
hair brush until a lather is formed , this usually takes five
minutes   Or the surface may be thoroughly cleaned with
bicarbonate lotion and silver nitrate 2 per cent , painted on
Daily application of a solution composed of equal parts of
0 5 per cent solution of crystal violet and brilliant green in
equal parts of alcohol and water, or a similar ointment (ung
tinctorium) has cured some cases   All loose lashes should be
pulled out with epilation forceps   If diplobacilli are present a
zinc lotion and ointment should be used   In the worst cases
X ray treatment will usually effect a cure

Attention must be directed to the hygienic surroundings and
to the general health   Errors of refraction must be corrected

Syphilis   A primary sore is occasionally found on the lid
margins commencing in the conjunctiva   It may be caused
by a kiss or by removing a foreign body with the tongue
There is generally a small ulcer, covered with scanty greyish
secretion and much indurated about the base   If situated
near the outer canthus the pre auricular gland is enlarged, if
near the inner canthus the submaxillary, in accordance with
the distribution of the lymphatic vessels   The swelling of the
glands is always suggestive of syphilis or tubercle, but in all
doubtful cases scrapings should be examined for spirochætes
and the blood examined by the Wassermann test   If recog
nised before the glands are affected the sore should be excised or
destroyed by radium   At a later stage calomel ointment should
be rubbed in   An energetic course of constitutional treatment
with X h B and mercury should be immediately instituted

Gummata occur in the lids sometimes, and occasionally
may cause enormous thickening of the tarsus (*syphilitic
tarsitis*)   Isolated gumma may be mistaken for a chalazion
In syphilitic tarsitis the lid may be so swollen and hard that
it is impossible to evert it   The pre-auricular gland is swollen
If the onset is slow there is little pain , sometimes the swelling

is rapid and very painful Gummata usually respond rapidly
to appropriate treatment with mercury and iodides

Vaccinia The margin of the lid is occasionally inoculated
from the recently vaccinated arm of a baby Often the
inoculated margin in turn inoculates the opposing margin
of the other lid Usually the pustule is at the outer canthus,
and the pre auricular gland is swollen and painful The
history generally serves to elucidate the case Sometimes
the cornea becomes affected a keratitis resembling disciform
keratitis resulting i e a grey disc denser at the margin

INFLAMMATION OF THE GLANDS OF THE LIDS

Hordeolum or stye is a suppurative inflammation of one of
Zeis's glands (Fig 334) In the early stages the gland becomes
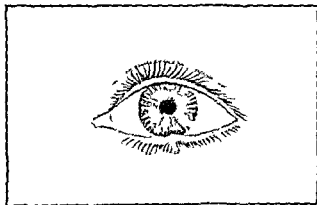
FIG 334 —Hordeolum

swollen hard and painful and usually the whole edge of the
lid is œdematous An abscess forms which generally points
near the base of one of the cilia

The pain is considerable until the pus is evacuated Styes
often occur in crops or may alternate with boils on the neck,
carbuncles or acne Like these conditions the disease shows
deficient resistance of the body to the invasion of staphylococci
It is commonest in young adults but may occur at all ages,
especially in debilitated persons Not infrequently it will be
found that faulty drains account for the defective health

Treatment Hot compresses should be used in the early
stages When the abscess points it may often be evacuated
by pulling out the corresponding cilium but this is usually
effected more satisfactorily by an incision with a small knife

It should be remembered that such an incision is very painful unless novocain or novutox has been injected. The pus should be thoroughly squeezed out and a hot compress applied.

If crops of styes occur the general health must receive attention. When associated with boils or carbuncles the urine should be tested for sugar especially in adults. Inquiry should be made as to the condition of the drains. Calx sulphurata in doses of gr $\frac{1}{4}$ to gr 1 certainly does good in some cases. In obstinate cases a staphylococcic vaccine *preferably autogenous should be used*

Constipation must be counteracted and tonics are useful especially iron in some form.

Hordeolum internum is comparatively rare. It is a suppura
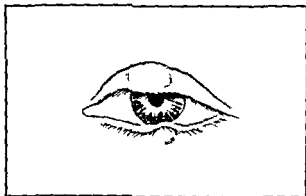
Fig 33. —Chalazion

tive inflammation of a Meibomian gland of exactly the same type as the hordeolum externum or stye. It is often called a suppurating chalazion and some may be due to secondary infection of a chalazion. The inflammatory symptoms are more violent than in external stye for the gland is larger and is imbedded in dense fibrous tissue. The pus appears as a yellow spot shining through the conjunctiva when the lid is everted. It may burst through the duct or through the conjunctiva *rarely through the skin*

Treatment is the same as for external type except that the incision should be made exactly as for a chalazion (*vide infra*)

Chalazion (*Syns —Tarsal Cyst Meibomian Cyst*) is a chronic inflammatory affection of a Meibomian gland. The gland tissue becomes replaced by granulation tissue containing giant cells, the disease is not caused by the tubercle bacillus but

is probably caused by the *chronic irritation* of an organism of low virulence The gland becomes swollen, increasing in size very gradually and without inflammatory symptoms Patients usually seek advice on account of the disfigurement (Fig 335) The smaller chalazia are difficult to see, but are readily appreciated by passing the finger over the skin If the lid is everted the conjunctiva is red or purple over the nodule, in later stages often grey, or rarely, if infection has occurred (*vide* Hordeolum internum), yellow The grey appearance is due to alteration in the granulation tissue This is not very vascular at any stage, but in the later stages the vessels retrogress, the nourishment of the tissue fails and it becomes converted into a jelly like mass Only under such conditions is the term "cyst" really applicable Complete spontaneous resolution very rarely occurs The contents may be extruded through the conjunctiva, and in these cases a fungating mass of granulation tissue often sprouts through the opening, keeping up conjunctival discharge and irritation Sometimes the granulation tissue is formed only in the duct of the gland, from which it projects as a reddish grey, somewhat translucent nodule on the intermarginal strip (*marginal chalazion*)

Chalazia are often multiple or occur in crops. They are commoner in adults than in children

Treatment Quite small chalazia may be left alone it is very difficult to evacuate them satisfactorily by the ordinary method Larger chalazia must be incised and thoroughly scraped The conjunctival sac is well anæsthetised with 2 per cent pantocain and a drop of adrenaline instilled The lid is then everted and the site of the chalazion carefully examined At the point of greatest discoloration a few crystals (not many) of
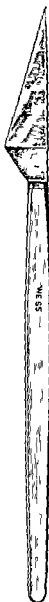
Fig 336 — Beer's knife (devised for cataract extraction now used only for lid operations)

solid cocaine are placed upon the surface and allowed to dissolve, or ¼ c c of 4 per cent novocain solution may be injected with a hypodermic syringe subconjunctivally in the retrotarsal fold in the vicinity of the chalazion This blocks the sensory nerve supply effectively except when the chalazion is near the nasal end of the lower lid, when a small subcutaneous injection should also be made A vertical incision is then made through the palpebral conjunctiva with a sharp scalpel or Beer s knife (Fig 336) Any semi fluid contents which may be present escape A small sharp spoon (Fig 337) is then inserted into the orifice and the walls of the cavity are thoroughly scraped The bleeding soon stops, and no dressing is usually necessary A simple boric acid lotion is ordered for a few days

The patient should be warned that the swelling will remain for a while This is due to the resistant walls, formed by the fibrous tissue of the tarsus , the cavity is thus kept dilated and becomes filled with blood Sometimes, especially if the scraping has not been sufficient granulation tissue sprouts from the wound This must be snipped off with scissors curved on the flat, after application of pantocain, the cavity should be again scraped out

Fic 337 — Sharp spoon

Very hard chalazia are occasionally met with, particularly near the canthi it is possible that some of these are true adenomata of the glands They may require excision, since it may be impossible to scrape them out efficiently

If a marginal chalazion is not treated the granulation tissue protrudes from the mouth of the gland and may organise into a greyish somewhat translucent lump of fibrous tissue on the lid margin It is disfiguring and rather difficult to remove without leaving an irregularity in the line of the lid It is best treated by diathermy, with a small needle as the active electrode A current of 200—300 milliamperes is passed for one second and the operation repeated if necessary

ANOMALIES OF POSITION OF THE LIDS

Trichiasis (θριξ, τριχος, a hair) is the condition of distortion of the cilia so that they are directed backwards and rub

against the cornea (*vide* p 179) A few only of the lashes may be affected, or the condition may be due to entropion involving the whole margin of the lid It may also be caused by congenital distichiasis (*vide* p 644)

The symptoms are those of a foreign body continually present in the eye—irritation pain, conjunctival congestion, reflex ble pharospasm, lacrymation Superficial opacities and vascularisation of the cornea are produced , recurrent ulcers of the cornea are not infrequently due to this cause

Any condition causing entropion (q v) will cause trichiasis, trachoma and spastic entropion being among the most common Other causes are blepharitis, and the scars resulting from injuries burns operations diphtheria &c

Treatment Isolated misdirected cilia may be removed by epilation which must, however, be repeated every few weeks A better mode of treatment is to destroy the hair follicle by diathermy or electrolysis With the former a fine needle is inserted into the hair follicle and a current of 150 milliampères is applied for one to two seconds With the latter the flat positive pole is applied to the temple , the negative a fine steel needle, is introduced into the hair follicle a current of two milliampères is used The negative pole is determined by placing the terminals in saline when bubbles of hydrogen are given off by it The strength of current can be gauged by the rate of evolution of gas It should be remembered that electrolysis is extremely painful and tedious , the pain may be avoided by injecting novocain into the margin of the lid If the current is of the proper strength, the bubbles evolved at the site of puncture cause the formation of a slight foam, and the lash with its bulbous root can be easily lifted out

Fig 338—Chalazion clamp useful for holding the lid everted in incising chalazia The ring is placed on the conjunctival surface and surrounds the chalazion

If many cilia are displaced, operative procedures must be resorted to Since they are nearly allied to those performed

for entropion, which is generally present, they will be described later (*vide* p. 626).

Entropion (ἐν, in, τρέπειν, to turn), rolling in of the lid, occurs in two forms, spastic and cicatricial. The symptoms are those of the trichiasis (*q v.*) which is induced.

Spastic entropion is due to spasm of the orbicularis. Strong contraction of the circularly arranged fibres tends not only to approximate the lid margins, but also to turn them inwards or outwards, according to the mechanical support afforded by the globe and orbital contents. If the support is insufficient, entropion is produced This is well seen when the eyeball has been removed, but it also occurs when the globe is deep'y set owing to absence of orbital fat, &c., especially if the skin of
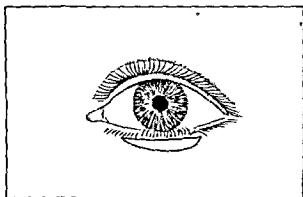
FIG 339 —Diagram of skin and muscle operation

the lids is also redundant. These conditions are found *par excellence* in old people, who are therefore very liable to spastic entropion It is also caused by tight bandaging, and is favoured by narrowness of the palpebral aperture (blepharo phimosis) Spastic entropion is almost invariably restricted to the lower lid

Cicatricial entropion is caused by cicatricial contraction of the palpebral conjunctiva; in the worst forms, found in trachoma, the tarsal plate is also bent and distorted, sometimes by atrophic, sometimes by hyperplastic, changes. It is an exaggeration of the effect produced by the various causes of trichiasis (*q v.*)

Treatment of Spastic Entropion If due to bandaging, the condition is often cured by simply leaving off the bandage. Wearing an artificial eye relieves the symptoms when the

eyeball has been removed In the spastic entropion of old people temporary relief may be obtained by placing a roll of lint or plaster horizontally just above the margin of the orbit, and bandaging it firmly in position , or the lid may be slightly everted by painting collodion on the skin or by pulling it out with a strip of adhesive plaster Injection of 1 c c of 80 per cent alcohol subcutaneously along the edge of the lid, with or without canthoplasty, has been advocated (Weekers)

Permanent relief can be obtained only by operation The simplest method is the removal of a strip of skin and muscle Pantocain is instilled and novocain injected subcutaneously An oval area of skin with the long axis horizontal and varying in width according to the amount of entropion and of superfluous skin is marked out with a scalpel or Beer's knife just below the site of greatest displacement The upper incision must be close to the margin of the lid (Fig 328) The piece of skin is dissected off The underlying fibres of the orbicularis are then dissected off with forceps and knife, until the tarsus is exposed Two or three sutures should be inserted

Wheeler's *operation* (Figs 341, 342) is less likely to be followed by recurrence A strip of orbicularis 4 mm wide is drawn upwards and outwards over the malar bone and secured to the periosteum by catgut sutures.

In cases of spastic entropion with much blepharospasm canthoplasty is sometimes indicated It consists in widening the palpebral aperture by dividing the outer

Fig 340 —Lid spatula which should be made of metal
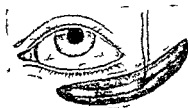
Fig 341

canthus   The lids are separated with the fingers in such a
manner as to put the canthus on the stretch. One blade of
strong blunt-pointed scissors is introduced as far as possible
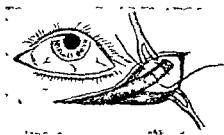
Fig 342

into the conjunctival sac behind the commissure. The entire
thickness, including skin and conjunctiva, is divided horizon-
tally by a single cut   If only a temporary effect is required,
no sutures are inserted.   If it is desired permanently to
enlarge the palpebral aperture, the conjunctiva is sutured to
the skin   Temporary canthoplasty is sometimes indicated in
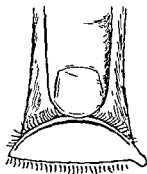
Fig 343 —Diagram of modi
fied Burow's operation for
entropion.

Fig 344. — Diagram of modified
Burow's operation for entropion.

other conditions than spastic entropion, e g , in simple severe
blepharospasm, such as occurs in phlyctenular conjunctivitis,
in acute purulent conjunctivitis with much swelling of the lids,
and in removal of an enlarged eyeball or an orbital tumour.

   Treatment of Cicatricial Entropion   Many plastic operations
have been devised for the relief of cicatricial entropion : only
the more simple will be described here.   The principles

governing the various operations are (1) altering the direction
of the lashes, (2) transplanting the lashes, (3) straightening the
distorted tarsus Subcutaneous injection of novocain or a
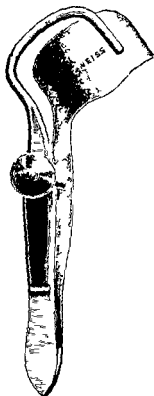
FIG 345 —Desmarres entropion forceps for right eye
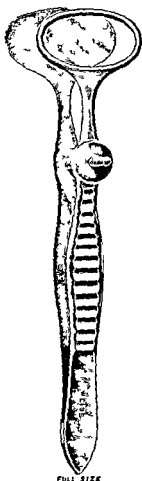
FIG 346 —Wilde's entropion forceps

general anæsthetic is indicated , the former method does not
obviate all pain, especially if the tarsus is cut

The simplest procedure is some modification of Burow's
operation The lid is everted over the end of a metal lid
spatula (Fig 340) A horizontal incision through the conjunctiva and passing completely through the tarsal plate,
but not through the skin, is made along the whole length

of the lid in the sulcus subtarsalis i e about 2—3 mm
above the posterior border of the intermarginal strip (Fig 343)
Care must be taken not to wound the punctum or canaliculus
The temporal end of the strip may then be divided by a
vertical incision through the free edge of the lid including the
whole thickness   In this manner the edge of the lid is left
attached only by skin and when cicatrisation has occurred
the edge is turned slightly outwards so that the lashes are
directed away from the eye   Relapses are not uncommon
however and the operation may have to be repeated   The
edge of the lid may be kept everted during the process of
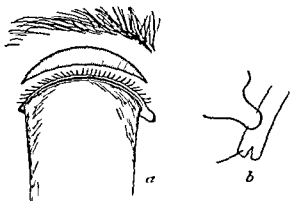
FIG 347 —Diagram of Jaesche Arlt operation for entropion

healing by means of a spindle shaped pad of oiled silk   The
pad is kept in position by sutures suitably applied

Fig 344 illustrates an alternative operation   The incision is
made as before   The tarsal plate is pared down to a chisel
edge along the whole length and mattress sutures are passed
through the plate and lid margin emerging through the grey
line (p 616) they are tied over glass beads thus bending the
lid margin forwards and upwards

In the Jaesche Arlt operation the zone of hair follicles is
transplanted to a slightly higher position   The lid is split from
the outer canthus to just outside the punctum along the grey
line (vide p 616) between the lashes and the orifices of the
Meibomian glands   During this procedure the globe is pro
tected by the spatula inserted between it and the lid or held by
a lid clamp (Figs 345 346)   The incision extends between the
ars is and the orbicularis for a depth of 3—4 mm , so that
the zone containing the hair follicles is thoroughly loosened

(Fig 347) A crescentic piece of skin is then removed from the lid. The lower incision extends through the skin down to the tarsus at a distance of 3—4 mm from the edge of the lid and parallel with it for its whole length. The middle part of the upper incision is 6—8 mm from the edge of the lid. The crescentic piece of skin thus marked out is removed, without taking any orbicularis. The two skin incisions are then sutured. In this manner the zone of lashes is transplanted to a higher level. The gaping wound in the intermarginal strip may be filled in with a graft of mucous membrane, this tends to prevent the follicles from being drawn down again when the wound cicatrises. Care should be taken not to produce ectropion by removing too much skin.

Ectropion, rolling out of the lid, occurs in several forms, the chief being spastic, cicatricial, senile, and paralytic. The symptoms are due to the epiphora induced and to the chronic conjunctivitis caused by exposure. In severe cases the cornea may suffer from imperfect closure of the lids.

Spastic ectropion results from blepharospasm when the lids are well supported by the globe and when they are short, firm, and without redundant skin. It is therefore seen in children and young patients, and is readily induced by phlyctenular conjunctivitis (*vide* p 168). Mechanical ectropion is caused by extreme proptosis or thickening of the conjunctiva, such as occurs after purulent conjunctivitis and trachoma. In the latter disease the tarsus is often distorted. Upper and lower lids are frequently affected simultaneously.

Cicatricial ectropion results from destruction of the skin by injury, burns, ulcers, gangrene, operations, &c. Caries of the orbital bones is a common cause in children. Chronic conjunctivitis and blepharitis also cause cicatricial ectropion, which is increased by the wetting of the skin with tears and the eczema thereby induced.

Senile ectropion is found only in the lower lid, and is due to relaxation of the tissues and degeneration of the orbicular muscle fibres. The condition is increased by the conjunctivitis and epiphora which are set up.

Paralytic ectropion results from the laxity of the lids induced by paralysis of the orbicularis. Only the lower lid is affected, the upper being kept in contact with the globe by its own weight.

In long standing cases of ectropion the exposed conjunctiva becomes dry and thickened, red and very unsightly.

Treatment Non operative treatment is chiefly serviceable

in spastic ectropion   Here a well fitting bandage, unless contra
indicated by other factors, will often cure the displacement
In ectropion paralyticum, the condition is cured only by
restoration of the innervation   The slighter degrees of senile
ectropion are also amenable to non-operative treatment,
though it may be advisable to slit the canaliculus in order to
cure epiphora (vide p 649)   The patient should be instructed
not to pull the lid down when wiping the eye

A large variety of operations has been devised for ectropion
only the simpler procedures will be described

Snellen s sutures are indicated in some cases of spastic and
senile ectropion   In this operation two loops of thread,
inserted at the junction of the middle with the inner and outer
thirds of the lid through the ectropionised conjunctiva, are
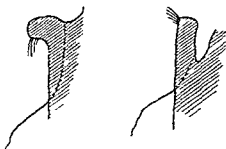
FIG 348 —Diagram of Snellen s sutures for ectropion.

made to hold the fornix in its proper position (Fig 348)   A
silk thread is armed with a needle at each end   One needle is
passed in at one of the two spots indicated at the level of the
top of the tarsus s e in the position where the fornix ought to
be   The needle is passed vertically downwards under the skin
and brought out just below the level of the orbital margin
The other needle is inserted similarly 2 or 3 mm to one side of
the first, and is carried down parallel with it   The second
suture is inserted in exactly the same manner at the junction of
the middle with the other third of the lid   The sutures are
then tied over pieces of rubber tubing laid vertically, the ectro
pionised fornix being thus drawn down into its normal position
The sutures may be tightened from day to day so as to cause
the formation of cicatricial bands along their tracks   This was
more effectual in the days when antiseptic precautions were not
observed   The effect is seldom permanent

In paralytic ectropion lateral tarsorrhaphy may be indicated

In this operation the palpebral aperture is shortened by uniting the lids at the outer canthus. The edges of the upper and lower lids are freshened for the requisite distance, the lashes being excised. The lids are then sutured together as in central tarsorrhaphy (*vide* p 227). The lower lid margin can be raised and the cornea better protected by using a strip of fascia lata 3 mm. wide sutured to the medial palpebral ligament and run subcutaneously beneath the lower lid margin and upwards and outwards over the malar bone : it is secured in the temporal fascia by weaving it in and out three or four times and then fixing it with catgut sutures Small incisions
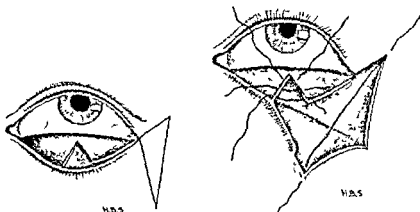
FIGS. 349, 350.—Dimmer's modification of Kuhnt's operation for ectropion

are necessary over the palpebral ligament, below the outer canthus, and over the temporal muscle at about the level of the highest point of the supraorbital margin A fascatome is needed for taking the graft and a special instrument for threading it subcutaneously

In many cases of ectropion, especially senile, the lower lid is stretched and elongated. The ectropion may then be cured by shortening the lid as in Dimmer's modification of Kuhnt's operation (Figs 349, 350) A triangular piece of conjunctiva and tarsus is excised, the apex of the triangle being towards the fornix. The lid is then split along the grey line from the triangle to the outer canthus. A triangular area of skin is removed at the outer canthus and the skin is slid outwards so that the gap in the tarsal plate is closed, the requisite length of the margin of the lid at the outer canthus being

denuded of cilia   Care should be taken to carry the upper
skin incision up and out, so that the lid will be drawn slightly
upwards   It is quite as effectual to remove the triangle of
tarsus at the outer canthus, and this avoids the necessity of
splitting the lid

In most of these operations restoration of the normal
position is facilitated by dissecting off the strip of thickened
conjunctiva at the margin of the lid

In the slighter cases of cicatricial ectropion the V—Y
operation of Wharton Jones is indicated (Fig 351)   A
V shaped incision, with the apex away from the lid margin, is
made through the skin, the limbs of the V enclosing the cicatrix
The skin is freed from the underlying tissues and is also well
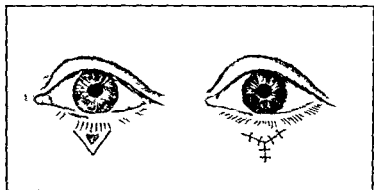
Fig 351 —Diagram of V—Y operation for ectropion

undermined at the edges   The margins of the incisions
are sutured in such a manner that a Y shaped cicatrix
results   the edge of the lid is thus raised to its normal
position

More extensive cicatricial displacement requires some form
of blepharoplastic operation, employing skin grafts (Wolfe or
Thiersch) or flaps of skin taken from the cheek or temporal
region or skin grafts employed   Each such case must be
treated on its own merits and will often exercise the ingenuity
of the surgeon

Symblepharon (συν, with, together, βλεφαρον, eyelid) is the
condition of adhesion of the lid to the globe (Fig 352)   Any
cause which produces raw surfaces upon two opposed spots of
the palpebral and bulbar conjunctiva will lead to adhesion if
the spots are allowed to remain in contact during the process

of healing Such causes are burns from heat or caustics, ulcers, diphtheria, operations, &c Bands of fibrous tissue are thus formed, stretching between the lid and the globe, involving the cornea if this has also been injured The bands may be narrow, but are more frequently broad, and may extend into the fornix so that the lid is completely adherent to the eyeball over a considerable area (symblepharon posterior) Bands limited to the anterior parts and not involving the fornix are called symblepharon anterior Total symblepharon, in which the lids are completely adherent to the globe, is rare

Pronounced adhesions cause impairment of mobility of the eye, so that diplopia may be complained of The adhesion may be so intimate that it is impossible to close the lids efficiently, lagophthalmia, with its baneful consequences, resulting There is often much disfigurement

Treatment The preven
tion of symblepharon is of
the utmost importance (*vide*
p 431) When it is already
established operation is
necessary Symblepharon
anterior is usually easily
remedied by dividing the
bands and preventing re
formation of adhesions in the
manner already described
When the bands are broad,
and especially if there is

Fig 352—Symblepharon

symblepharon posterior, the separation of the lid from the globe is difficult There is no guide to the limitations of sclerotic and tarsus and great care has to be exercised lest the globe be punctured The prevention of re formation of adhesions is much more difficult, and is successful only if the raw surfaces are covered with conjunctival or mucous membrane grafts (*vide* p 431)
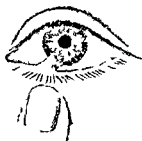
Ankyloblepharon (ἀγκύλη, a thong βλέφαρον, eyelid) is adhesion of the margins of the two lids It may be either a congenital condition or due to burns, &c It may be partial or complete, and is often combined with symblepharon The treatment depends upon the amount of symblepharon If it is very extensive operation may be contraindicated In other cases the lids are separated and kept apart during the healing process If the adhesion extends to the angle of the lids the

latter must be covered with an epithelial graft, otherwise the condition will recur

Blepharophimosis (βλέφαρον eyelid, φῖμος, a muzzle) is the condition in which the palpebral fissure appears to be contracted at the outer canthus The outer angle is really normal, but is obscured by a vertical fold of skin The latter is due to eczematous contraction of the skin following prolonged epiphora and blepharospasm Mere narrowing of the palpebral aperture is often called blepharophimosis, and may be a congenital condition it is really a form of ankyloblepharon

The condition may require no treatment, disappearing spontaneously after the inflammation has subsided In other cases canthoplasty is indicated

Lagophthalmia (λαγως, a hare) is the condition of incomplete closure of the palpebral aperture when the eyes are shut It may be due to narrowing of the lids from cicatrisation or congenital deformity, ectropion, paralysis of the orbicularis, proptosis due to exophthalmic goitre orbital tumour, &c , or to laxity of the tissues and absence of reflex blinking in people who are extremely ill or moribund Owing to exposure the cornea becomes epidermoid (xerosis corneæ) or keratitis sets in The treatment is that of keratitis e lagophthalmos (q v)

Ptosis (πιπτειν, to fall) is the term given to drooping of the upper lid due to paralysis or defective development of the levator palpebræ superioris Ptosis may also be caused by thickening and increased weight of the lid (vide p 619) The condition may be unilateral or bilateral, partial or complete In the higher degrees the lid hangs down, covering the pupil more or less completely and interfering with vision An attempt is made to counteract the effect by overaction of the frontalis and by throwing back the head, the eyes being pulled downwards by the inferior recti A very characteristic attitude is thus adopted Forced contraction of the frontalis causes the eyebrows to be raised and throws the skin of the forehead into wrinkles Partial ptosis may be masked by this means, but becomes manifest if the patient is asked to look up while the eyebrows are fixed by firm pressure with the fingers against the bone

Ptosis may be congenital or acquired The congenital form is usually but not invariably, bilateral and is due in most cases to defective development of the muscles Some cases have been proved to be caused by maldevelopment of the third nucleus The condition is not infrequently hereditary There is nearly always defect in the upward movement of the eyes,

due partly to absence of the posterior insertion of the levator into the fornix (*vide* p 617), partly to coincident maldevelopment or defective innervation of the superior rectus   It may be pointed out here that defective upward movement of the eye is the commonest congenital defect of bilaterally associated extrinsic muscles

Acquired ptosis is usually unilateral   It may be part of the symptom complex of paresis or paralysis of the whole of the third nerve, or may be due to paresis or paralysis of the branch supplying the levator   Isolated ptosis without other signs of oculomotor paralysis may result from disease of upper level centres (cerebral ptosis)   Acquired ptosis may also be due to direct injury of the muscle or its nerve supply, as by wounds, fractures, &c   Mechanical ptosis is due to deformity and increased weight of the lid brought about by trachoma, tumours, &c , it also occurs from lack of support in phthisis bulbi, anophthalmia, &c   Bilateral ptosis may occur in the acquired form, notably as part of the syndrome of myasthenia gravis

The amount of ptosis sometimes alters with the position of the globe, attaining its highest pitch in abduction of the eye, its least in adduction or attempted adduction   Occasionally in both the congenital and acquired forms the lid rises when the jaw is moved, as in mastication, though it remains immobile when an attempt is made to look upwards (*vide* p 563)   This is an example of synkinesis or associated movement

Treatment   In cases of paralysis of the third nerve treatment must be directed to removal of the cause   The fact that this nerve is so frequently affected in syphilis must be borne in mind , these cases respond to treatment better than others   In cases of incurable paralysis and in congenital and mechanical ptosis the deformity can be removed only by operation   In complete paralysis of the third nerve operation is usually contraindicated on account of the abduction of the eye   If the lid is raised in these cases the diplopia becomes manifest , simultaneous advancement of the internal rectus may diminish the diplopia and the deformity, but is unsatisfactory and unlikely to give a permanent result

Operations for ptosis ameliorate the condition but seldom give permanent results   In slight cases excision of an elliptical area of skin, with or without excision of the underlying fibres of the orbicularis, improves the appearance temporarily

Of the many operations which have been devised for the more severe cases Hess's operation is one of the simplest   The eye-

brow is shaved   An incision is made in the line of the eyebrow
for 2 5 cm   The skin of the lid is then undermined through this
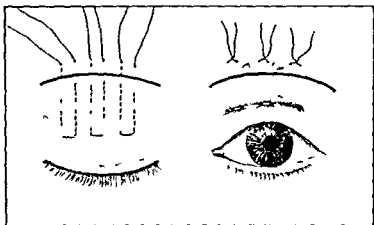
Fig 353 —Diagram of Hess's operation for ptosis

incision so that it is completely separated from the orbicularis and
tarsus over its whole area   Three silk sutures are then inserted
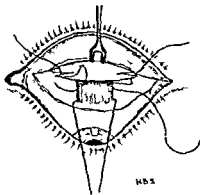
Fig 354 —Showing the controlling suture and the exposed rectus
tendon.

as shown in Fig 353 , or the lid may be raised by narrow strips
of fascia lata similarly inserted

A better but more difficult operation is Greeves's modification
of Motais'   A controlling suture is first inserted in the con

junctiva immediately above the cornea and the eye depressed
as far as possible by its means The superior rectus tendon and
its attachment to the globe are then exposed by a horizontal
incision through the conjunctiva and a silk thread is then passed
under the tendon   the two ends of the thread being secured by
Spencer Wells forceps

Next the upper lid is everted and the conjunctiva above the
incision seized by forceps and dissected upwards until the upper
edge of the tarsal plate is exposed

The upper edge of the tarsal plate appears as a convex rounded
border this is gripped centrally by catch forceps on each side
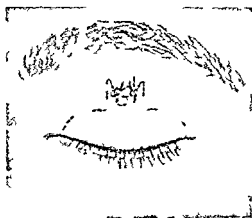
Fig 355 —The dotted lines indicate the position of the tarsal plate
   tarsal strips superior rectus tendon and sutures when the
   operation is completed   (Greeves)

of which a thin strip of tarsus is cut with a fine pair of bent
scissors from without inwards and within outwards respectively
each strip being left attached centrally (Fig 354) the width of
the uncut area of tarsal plate between the strips being about the
same as that of the superior rectus tendon as long a strip of tarsal
tissue as possible should be aimed at   A No 4 needle threaded
with No 1 silk is then passed through the end of one of the
strips and again through the corresponding edge of the
superior rectus tendon a similar suture being passed through the
other strip and the other edge of the tendon (Fig 355)   The
sutures are drawn tight without being tied in order that a judg
ment may be made of the relative positions of the eye and eyelid
the position of the edge of the lid should be such that it slightly
overlaps the upper part of the cornea If the position of the lid
is judged not to be correct those parts of the sutures which have

been passed through the tendon should be withdrawn and re inserted in the tendon in a suitable position, either higher up or lower down as required

After healing has taken place and all reaction has disappeared, it will frequently be found that when the eyeball is raised, the skin of the upper lid is apt to fall in an unsightly fold over the lashes ; the skin is flabby and does not seem to possess a normal tone   A horizontal strip of skin of suitable width is removed from the upper lid, the position of the lower skin incision corresponding roughly to that of the upper edge of the tarsal plate   The sutures which join the edges of the skin incision are carried through the deep tissues in such a way as to stretch the skin over the tarsus and to produce a fold in the skin of the eyelid in the normal position

INJURIES OF THE LIDS

Injuries of the most various kinds—contusions, wounds, burns, &c —are very common   They must be treated upon general principles, but special attention must be directed to three points—(1) wounds of the skin of the lids, (2) injury of the bones of the orbit, (3) injury of the eyeball

Wounds in the direction of the fibres of the orbicularis gape little and heal without conspicuous scarring , hence surgical wounds should be made in this direction as far as possible   Vertical wounds gape, cause disfiguring cicatrices, and often lead to ectropion, or other distortion, especially if there is adhesion to the subjacent bone   The worst wounds are such as sever the lid vertically in its whole thickness   If they do not unite by first intention a notch (traumatic coloboma) is left in the lid margin, and disfigurement, lagophthalmia, and epiphora result   Vertical wounds severing the canaliculus require special care (*vide infra*)

Injury to the bones of the orbit may affect the orbital margin or deeper parts   Fractures involving the margin may be diagnosed by careful palpation—unevenness, crepitation, &c   Fractures of the walls of the orbit often manifest themselves by *emphysema*   It is due to communication of the subcutaneous tissues with the nasal air sinuses, air being forced into the tissues on blowing the nose, sneezing, straining, or coughing   There is great swelling with a peculiar soft crepitation on palpation.   Fracture of the orbital bones may be followed by retraction of the globe (traumatic enophthalmos), or may be part of a more serious fracture of the base of the skull   In the latter event the optic foramen is often involved, causing laceration or compression of the optic nerve (*vide p* 401)

Injuries involving the globe require special care both in diagnosis and treatment In every case of injury of the lids the eyeball must be very carefully examined Palpation, which should be very gentle, will usually demonstrate considerable reduction of intraocular pressure if the eye is injured, it indicates rupture of the globe Inspection may be difficult on account of excessive swelling and ecchymosis In such cases the eye must be examined at all costs, the lids being separated by retractors, under an anæsthetic if necessary

Contusions are often more alarming in appearance than in reality There is great swelling and ecchymosis both in the lids and conjunctiva In all cases a guarded prognosis should be given, for it may be impossible to determine the full extent of the injury to the orbit (*vide* p 668), or the eye (*vide* p 432)

Treatment Simple contusions with ecchymosis require only cold compresses a simple boric lotion is ordered for cleansing the conjunctival sac, and boric ointment to prevent the lids from sticking together

Emphysema should be treated with a pressure bandage, and all straining, blowing of the nose, and so on, must be avoided

Wounds must be thoroughly cleansed with an antiseptic lotion and brought together by sutures On account of the rich blood supply it is not necessary to make such a wide excision of the edges of a wound of the lid as it is elsewhere only obviously contused and devitalised tissue should be excised As a prophylactic against infection the wound should be dusted with sulphonamide powder In wounds involving the canaliculus the inner cut end must be searched for, and the canaliculus slit up (*vide* p 649) If this is not done before cicatrisation has occurred epiphora will follow, and it will be extremely difficult to obtain an entry into the canaliculus in order to slit it up Lacerated wounds are likely to leave ugly scars and deformity of the lids these must be treated by plastic operation If suppuration occurs the abscess must be opened and treated on general surgical principles

Burns It is important to diagnose the degree of a burn First degree burns require cleansing and the application of sterile saline packs every three hours during the day Second degree burns should be cleansed, vesicles opened, and dead epithelium removed On no account should any coagulant such as tannic acid, tannafax, &c, be used on the lids It makes them rigid and immobile, so that it is impossible to apply satisfactory treatment to the eye, and much distortion of the lids follows Gentian violet (2 per cent) or triple dye

jelly (vide p 689) may be used with advantage   In third degree burns, after thorough cleansing and removal of dead tissue, a Stent mould is taken of the denuded area and a Thiersch graft applied (vide p 507)   A temporary tarsor-rhaphy, permitting some access to the conjunctival sac for treatment is helpful, and may be released when risk of cicatricial ectropion is past   A Thiersch graft relieves the pain considerably   The dressing (vide p 507) over the graft is not changed for five or more days   Cicatricial deformities resulting from burns are corrected by plastic operation

TUMOURS OF THE LIDS

Benign tumours include xanthelasma, molluscum warts nævus, angioma, and other tumours common to the skin and cutaneous glands

Small clear *cysts* frequently occur among the lashes in old people, due to the retention of secretion of Moll's glands   They disappear if the anterior wall is snipped off

Xanthelasma (ξανθος, yellow, ἐλασμα, a plate) or xanthoma is a slightly raised yellow plaque, most commonly found in the upper and lower lids near the inner canthus and often symmetrical in the two lids and on both sides   The plaques are most common in elderly women   They grow slowly, and only require treatment on account of the disfigurement produced   They are sometimes associated with diabetes and excessive formation of cholesterin   They may be removed after sub-cutaneous injection of novocain, or destroyed by electrolysis or radium

Molluscum contagiosum is a small white umbilicated tumour, generally multiple   A substance resembling sebum can be squeezed out of it   Each tumour should be squeezed out after incision and the interior touched with solid silver nitrate stick

Nævus or mole usually pigmented, may occur on the lids, generally affecting the margin and involving both skin and conjunctiva   Two are often symmetrically situated on the lids of the same eye, indicating their origin at a time when the lids were still united   The microscopical appearance is charac-teristic, consisting of ' nævus cells " often arranged in an alveolar manner   The growths very rarely take on malignant proliferation   They may be removed by diathermy

Hæmangioma, often also called nævus, occurs in two forms —telangiectasis and cavernous hæmangioma   The former are bright red or port wine coloured spots composed of dilated

capillaries   The latter consist of dilated and anastomosing venous spaces lying in the subcutaneous tissue having all the characteristics of erectile tissue , they are not infrequently strictly localised as if partially encapsuled   They appear bluish when seen through the skin and form a swelling which increases in size on crying lowering the head &c   Cavernous hæmangiomata are rarely seen in adults partly due to the fact that they are generally treated in early life but possibly due to spontaneous atrophy of the growth and thickening of the skin

Hæmangioma often follows the distribution of the first and second divisions of the Vth nerve   It may be associated with hæmangioma of the choroid and buphthalmia and also with hæmangioma of the occipital cortex causing homonymous hemianopia   The intracranial masses may be revealed radiographically since they often contain calcareous deposits

Telangiectases may be excised if small or treated with radium though radium applied near the eye may cause irradiation cataract   Electrolysis or carbonic acid snow may also be used   Cavernous hæmangioma may be excised preferably from the conjunctival surface if small   If larger they may be treated by electrolysis   It is a good plan to use electrolysis for a time until the tumour is consolidated with fibrous tissue and then to excise the mass

Lymphangioma occurs rarely in the lids

Symmetrical soft swellings above the inner canthus are sometimes seen in elderly people   They are due to prolapse of the orbital fat through an aperture in the fascial septum

Malignant Tumours include carcinomata and sarcomata the former being much the more common   Epitheliomata (squamous celled carcinomata) show a preference for spots where the character of the epithelium changes   they therefore commence generally at the edges of the lids   The patients are elderly   the preauricular gland may be enlarged or if the growth is near the inner canthus the submaxillary lymphatic glands   Any of the glands of the lid may in rare instances undergo carcinomatous proliferation

The commonest malignant epithelial growth is the so-called rodent ulcer (basal celled carcinoma) which shows a predilection for the inner canthus   It commences as a small pimple which ulcerates   If the scab is removed it is found that the edges are raised and indurated   The ulcer spreads very slowly the epithelial growth extending under the skin in all directions and penetrating deeply   The surrounding structures are gradually destroyed   lids orbit and bones are invaded

The growth is only locally malignant and probably originates in the accessory epithelial structures of the skin—hair follicles and glands The lymphatic glands are not affected Rodent ulcer rarely occurs before forty years of age, and the rate of growth is of the order of years

Sarcoma is rare , it may be round or spindle-celled, pigmented or non pigmented Round-celled growths, variously described as lymphoma, lymphosarcoma, pseudo leukæmic tumours, &c, sometimes affect both orbits and all four lids causing symmetrical proptosis Occasionally the patients show blood changes as in leukæmia but these are usually absent The growth is slow but continuous, and the eyes are lost from lagophthalmia The malignant growths springing from nævi are usually called sarcomata

Treatment Epithelioma and sarcoma must be thoroughly extirpated by diathermy at all costs, even if it involves excision of the globe or exenteration of the orbit Rodent ulcer, if small, should be excised If larger, so as not to be amenable to operative treatment without sacrificing a good eye, it may be treated with radium or X rays for a time, provided there is no involvement of the bones Considerable improvement, and even cure, has been reported from this treatment, but there can be no doubt that the results may be seriously misleading The skin surface may show a firm scar, while the growth continues to spread beneath the surface In any case it is wise to excise the scar freely after radium treatment, and for many months to keep a careful watch for any recurrence In the later stages extensive plastic operations may have to be performed to protect the eyeball When this becomes impossible the eye must be excised and the morbid tissues freely removed

Congenital Abnormalities of the Lids

Symblepharon, ankyloblepharon, ectropion, entropion and trichiasis occur occasionally as congenital malformations Ptosis is a fairly common congenital defect

Distichiasis {ευς, double, στιχος, a row} is a rare condition in which there are two complete rows of cilia often in all four lids The posterior row occupies the position of the Meibomian glands which are reduced to mere sebaceous glands performing the normal function of lubricating the hairs It causes trouble by rubbing against the cornea

Coloboma of the lid is a notch in the edge of the lid The

gap is usually situated to the inner side of the middle line generally affecting the upper lid Two or more defects may occur in the same lid Sometimes a bridge of skin links the coloboma to the globe, or there is a dermoid astride the limbus at the site of the coloboma There are often other congenital defects of the eye or other parts of the body, *e g*, coloboma of the iris, accessory auricles, &c Some cases are due to incomplete closure of the fœtal facial cleft, others probably to pressure of amniotic bands Occasionally there is a notch at the outer part of the lower lid, associated with maldevelopment of the malar bone

Cryptophthalmia (κυπτος, hidden) is a very rare condition in which there is total ankylo and sym blepharon, associated with abnormality of the eye and often of the orbit The skin passes continuously from the brow over the eye to the cheek

Microblepharon is the condition in which the lids are abnormally small They may be absent—*ablepharon* These conditions usually occur only in cases of microphthalmia, or congenitally small eyes Microphthalmia may be associated with a congenital *orbito-palpebral* cyst, causing a swelling of the lower lid The cyst is connected with the eyeball, contains retinal tissue in its lining, and is due to defective closure of the fœtal fissure—an extreme case of ectatic coloboma of the choroid (η υ) The eye ball may be apparently absent (*congenital anophthalmia*), but there are always microscopic vestiges of ocular tissues

Epicanthus is a semilunar fold of skin, situated above and sometimes covering the inner canthus It is usually bilateral, the eyes are far apart, and the bridge of the nose is flat It may disappear as the nose develops It is normal in Mongolian races

Neurofibromatosis (*Syns —Elephantiasis neuromatodes, plexi form neuroma, von Recklinghausen's disease*) may affect the lids and orbit In typical cases the temporal region is also affected The swollen lid and temporal region form a characteristic picture The hypertrophied nerves can be felt through the skin as hard cords or knobs The nerve fibres are little changed, the hyperplasia affecting the endo and peri neurium In several cases the ciliary nerves have been found affected, both in the orbit, asso ciated with true glioma of the optic nerve, and inside the globe, which in many cases has been buphthalmic Operative measures are seldom satisfactory The choroid and ciliary body may be much thickened by layers of dense nucleated fibrous tissue, probably derived from the cells of the sheath of Schwann (*vide* p 419) Laminated ovoid bodies resembling Paccinian corpuscles also occur

CHAPTER XXXII

Diseases of the Lacrymal Apparatus

Anatomy and Physiology. The lacrymal apparatus consists of the lacrymal glands and the lacrymal passages

The *lacrymal glands* of each eye consist of the superior or orbital gland, the inferior or palpebral gland, and the accessory lacrymal glands or Krause's glands All are serous acinous glands scarcely distinguishable, microscopically, from serous salivary glands, with which they are morphologically identical The superior gland, about the size of a small almond, is situated in the lacrymal fossa at the outer part of the orbital plate of the frontal bone , Ten or twelve *lacrymal ducts* pass from it to open upon the surface of the conjunctiva at the outer part of the upper fornix The inferior gland consists of only one or two lobules situated upon the course of the ducts of the superior portion It can be seen when the eye looks down and in after the upper lid has been everted The accessory or Krause's glands are microscopic acini, lying below the surface between the fornix and the edge of the tarsus There are about forty two in the upper, six to eight in the lower, fornix The ducts of numerous acini unite to form a larger duct which opens on to the fornix

The lacrymal passages consist of the puncta lacrymalia, the canaliculi, the lacrymal sac, and the nasal duct (Fig 356) The *puncta lacrymalia* lie near the posterior border of the free margin of the lid about 6 mm from the inner canthus Each lid has one punctum and one canaliculus The punctum is situated upon a slight elevation, larger in elderly people, the papilla lacrymalis As already mentioned, this is visible under normal circumstances only when the lid is slightly everted (video 8½) The *canaliculus* passes from the punctum to the lacrymal sac It is first directed vertically for about 1 to 2 mm , then horizontally for 6 to 7 mm The canaliculi usually open separately through the outer wall of the lacrymal sac The *lacrymal sac* lies in the lacrymal fossa formed by the lacrymal bone When distended it is about 15 mm long vertically, and 5 to 6 mm wide The fundus extends slightly

above the level of the inner tarsal ligament   The sac is surrounded by fibres of the orbicularis   The lower end narrows as it opens into the nasal duct.   The *nasal duct*, varying much in size (12 to 24 mm long, 3 to 6 mm in diameter), passes downwards and slightly outwards and backwards, bounded by the superior maxilla and inferior turbinate, to open at the anterior part of the outer wall of the inferior meatus of the
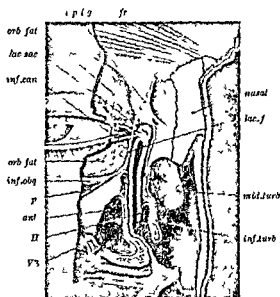
Fig 356—Canaliculi lacrymal sac and nasal duct   *V 3* infraorbital nerve ,   *H* valve of Hasner   *ant ,* antrum ,   *inf obq ,* inferior oblique, *orb fat* orbital fat,   *inf can* inferior canaliculus ,   *lac sac,* lacrymal sac ,   *i p lig ,* internal palpebral ligament (turned up) ,   *fr ,* frontal process of *superior maxilla   nasal* nasal bone ,   *lac f,* lacrymal fascia,   *mid turb* middle turbinate bone ,   *inf turb* inferior turbinate bone ,   *p ,* periorbita   (Eugene Wolff   " Anatomy of the Eye and Orbit   Lewis London)

nose.   The line of the duct is given by a point just outside the inner canthus and the groove between the ala of the nose and the cheek.   The upper end of the nasal duct is the narrowest part.   The canaliculi are lined by stratified epithelium, the lacrymal sac and nasal duct by columnar epithelium, lying upon a corium which contains a venous plexus   The mucous lining forms an imperfect valve at the orifice into the nose

The *lacrymal secretion* is a slightly alkaline fluid containing sodium chloride as its chief constituent.   The ordinary amount secreted is just sufficient to moisten the eyeball, and is lost

by evaporation   Only under reflex irritation, psychical or peripheral, is an excess secreted, and this is forced into the lacrymal sac and through the nasal duct into the nose during the act of winking, when the fibres of the orbicularis contract around the sac   It must be remembered that xerosis or dryness of the conjunctiva does not result from extirpation of the superior and inferior lacrymal glands, the moistening of the conjunctiva by Krause's glands and its own mucous cells being sufficient to prevent it   *Per contra*, epiphora does not result from extirpation of the lacrymal sac, except in the presence of psychical or peripheral stimuli to increased secretion   The tears have some slight antiseptic properties, owing to the presence of lysozyme

DISEASES OF THE LACRYMAL GLAND

Diseases of the lacrymal gland are rare   *Dacryo-adenitis* occurs occasionally, usually going on to suppuration   Tubercle also occurs here   A permanent *fistula* may result from rupture of an abscess in the gland   Spontaneous and traumatic *dislocation* of the gland have been described, a swelling being formed under the outer part of the upper lid

Dacryops is a cystic swelling in the upper fornix, due to retention of secretion owing to blockage of one of the lacrymal ducts   It can only be distinguished from retention cysts of Krause's glands by its position

Tumours of the lacrymal gland show a very marked resemblance to those of the parotid   In *Mikulicz' disease* there is symmetrical enlargement of the lacrymal and salivary glands probably of a lymphomatous nature   Both parotid and lacrymal glands are enlarged in uveo-parotid inflammation (*vide* p 275)   Mixed tumours in reality endotheliomata, containing cartilage myxomatous material, &c, are the commonest form   Carcinomata and sarcomata are very rare

All conditions which cause swelling of the gland may lead to impairment of movement of the eye   The globe is pushed downwards and inwards, movement outwards, and especially outwards and upwards, is limited   There may be some *proptosis.*

The rare diseases mentioned above must be treated on general principles

DISEASES OF THE LACRYMAL PASSAGES

Eversion of the lower punctum occurs from laxity of the lids in old age, from chronic conjunctivitis, blepharitis, and any

cause leading to ectropion ($q\imath$) It causes epiphora, which in turn aggravates the condition (*vide* p 631)

Treatment In slight cases, especially in old people, the eversion may be sufficiently counteracted by making a small scar in the fornix just behind and below the position of the punctum This is best done with the actual cautery, a fairly deep gutter being made As the cicatricial tissue contracts the punctum is pulled inwards towards the eye

If this fails the canaliculus should be slit up, the object being to bring the opened duct into apposition with the globe It is therefore most important that the canaliculus should be slit up through its *posterior* wall

The simplest method is the so-called "three-snip" operation The vertical part is opened up, and then the horizontal part for 2 mm This forms a triangular flap which is snipped off with scissors

More extensive slitting of the lower canaliculus is performed as follows

Instruments required Nettleship's dilator (Fig 357) canaliculus knife (Fig 358) The best form of canaliculus knife is the modification of Weber's in which the probe point is straight, not curved forwards as in the original instrument (Fig 358) Pantocain is instilled into the conjunctival sac and novocain injected into the tissues around the canaliculus The surgeon stands behind the patient In operating upon the right side he everts the lower lid with his left thumb With the right hand he inserts the point of Nettleship's dilator into the punctum passing it directly downwards as far as it will go easily, then rotating it outwards and pushing it inwards along the canaliculus In this manner the punctum is dilated. The knife is then taken and the probe point is passed into the punctum in the same manner, first downwards, then inwards The back of the knife is directed forwards and slightly downwards In this manner, as the knife is pushed inward, the posterior wall of the canaliculus is incised While this manoeuvre is being performed the lid is kept stretched out-

Fig 357 —Nettleship's canaliculus dilator

wards so that the wall of the duct is kept taut against the edge of the knife Care must be taken that the edge of the knife which is directed towards the globe does not injure the eye though there is little danger of such an accident

A probe should be passed along the incised canaliculus on the day following the operation and occasionally on succeeding days so as to prevent closure of the incision

Under no circumstances should the canaliculus be slit up unless it is absolutely necessary It should never be slit up *more* than is absolutely necessary

In some cases of eversion of the lower punctum a radical operation for ectropion may be necessary

Occlusion of the puncta may be congenital which is extremely rare or cicatricial Epiphora is caused These cases are very difficult to treat An endeavour should be made to slit up the occluded punctum—not the whole canaliculus On inspection no trace of the punctum may be visible but it is rare that some evidence of its presence cannot be seen on minute examination of the normal site with a loupe The point of the dilator is inserted at this site and may succeed in opening up the punctum sufficiently to admit the probe point of the canaliculus knife There is usually no difficulty in knowing when the knife is in the duct as it passes on in the proper direction quite easily If this method fails to permit an entrance the canaliculus may be cut across vertically When bleeding has stopped the inner cut end is examined with a loupe and the probe point of the knife is inserted into it If this also fails and the upper punctum is patent an attempt may be made to pass a small curved probe by the upper punctum into the sac and out into the lower canaliculus

Fig 3 8 — Tweedy's canaliculus knife

Occlusion of the canaliculus may be due to a scar (*vide* p 640) or to a foreign body Of the latter an eyelash is the commonest less frequent a concretion An eyelash usually projects somewhat from the punctum and is easily removed with forceps Concretions are masses of the mycelium of a fungus usually a streptothrix They are removed by dilating the canaliculus and injecting 10 per cent protargol

Congenital anomalies of the puncta and canaliculi are

occasionally met with. The puncta may be absent or constricted; there may be two puncta in a lid, generally opening into the same canaliculus. Sometimes a groove is found instead of a canaliculus.

Dacryocystitis or inflammation of the lacrymal sac is not uncommon, especially among the lower classes. It is generally chronic. There is epiphora, aggravated by exposure to wind, &c. Usually there is swelling at the site of the sac. Often the caruncle and neighbouring parts of the conjunctiva are inflamed. On pressure over the sac, fluid regurgitates through the puncta, or more rarely passes down into the nose. The fluid may be tears, mucus, or muco-pus; the swelling is often called a *mucocele*. Bacteriological examination of the fluid demonstrates the presence of an extraordinary number of bacteria—staphylococci, pneumococci, streptococci, &c. Of these the pneumococcus is very frequently present in virulent form. This fact is of supreme importance, since it explains the frequency with which hypopyon ulcer arises in these cases, and the danger of panophthalmitis if any intra-ocular operation is undertaken. Dacryocystitis is a constant menace to the eye, since minute abrasions of the cornea are of almost daily occurrence, and such an abrasion is liable at any moment to become infected and give rise to an hypopyon ulcer.

Chronic dacryocystitis is commonly attributed to the effects of stricture of the nasal duct. It is by no means certain that the stricture is primary in all these cases; it is not unlikely that it sometimes results from the inflammation of the sac or from the treatment applied to remedy the dacryocystitis. It might be anticipated that the infection was frequently derived from the nose in cases of ozaena, &c., but investigation tends to negative this conjecture. There are, however, many undoubted cases in which intractable dacryocystitis has been cured by treatment of a coincident nasal inflammation.

FULL SIZE

FIG. 350.—Couper's lacrymal probes.

Obstruction to the lower end of the nasal duct may be caused by the pressure of nasal polypi, an hypertrophied inferior turbinate bone, extreme deviation of the septum, and so on

Untreated chronic dacryocystitis never undergoes spontaneous resolution The condition tends to progress, the walls of the sac ultimately become atonic, the contents never being evacuated except by external pressure In any case an acute inflammation may arise, a lacrymal abscess being formed This sequel may be caused by treatment, an abrasion of the epithelial lining leading to infection of the pericystic tissues

The patients are usually elderly, and such as are exposed to dirt in the course of their daily occupations Want of personal cleanliness is probably an important factor Dacryocystitis may, however, occur in the new born In these cases it is generally due to adhesion of the epithelial lining, or to imperfect canalisation of the epithelial cord in which the nasal duct is formed The careful passage of a small probe *once* will cure these cases Occasionally dacryocystitis in babies is extremely intractable I am of the opinion that most of these cases are tuberculous or syphilitic, usually originating in caries of the surrounding bones

Tubercle of the lacrymal sac also occurs in adults as a rare form of dacryocystitis

Treatment In the new born a simple boric lotion should be ordered, and minute directions should be given for expressing the contents of the sac, which should be done very frequently Many cases will be cured by this treatment If it fails after a fortnight, an anæsthetic should be given and a small probe passed down the nasal duct, the greatest care being exercised to avoid injuring the walls of the duct It is unnecessary to slit up the canaliculus The punctum and canaliculus are dilated with a Nettleship's dilator A small probe (No 1 or 2) is inserted vertically downwards into the canaliculus, then passed gently but firmly inwards until the point is felt against the lacrymal

FULL SIZE

Fig 360 — Luer's syringe, with nozzle, for syringing the lacrymal passages.

bone The probe is then rotated upwards and towards the middle line and pushed down the nasal duct until it touches the floor of the nose It should be remembered that the duct is short in the new born The force required is quite slight if rightly applied in the line of the duct (*vide* p 647) Since much harm may be done by bad probing these cases should be treated by an expert

In adults the conjunctival sac should be anæsthetized The punctum is dilated and the sac syringed out with a lacrymal syringe (Fig 360) A moderately fine straight cannula should be used The point is inserted into the canaliculus it need not pass into the sac Two or three syringefuls of boric lotion are passed Probably the whole of the fluid will regurgitate through the upper canaliculus The operation should be repeated every day for a fortnight or longer In the majority
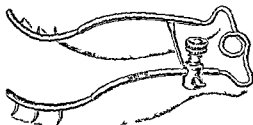
Fig 361 —*Briggs's retractor*

of cases the fluid will pass freely down into the nose in a few days When this occurs the syringing should be repeated at constantly increasing intervals A great number of previously untreated cases can be cured in this manner The patient should be told to squeeze out the contents of the sac frequently in the intervals between syringing

The rationale of this treatment depends upon the fact that the walls of the sac and upper part of the duct are inflamed The swollen mucous membrane prevents the fluid in the sac from passing into the nose The treatment reduces the swelling and restores the communication If it is unsuccessful after trial for a week or fortnight protargol (10 to 20 per cent) should be used for syringing occasionally instead of boric lotion

If syringing fails the condition of the nasal fossæ should be thoroughly investigated by an expert and any pathological condition likely to cause inflammation or obstruction of the nasal duct treated

If no cause is discovered in the nose either excision of the lacrymal sac or the establishment of permanent drainage into the nose by dacryocystorhinostomy must be undertaken The radical operation, properly performed, completely removes the disease, with a minimum of inconvenience to the patient

Many surgeons treat chronic dacryocystitis by probing The canaliculus is slit up, and probes of increasing calibre are passed down the nasal duct into the nose (Fig 359) The objections to this method of treatment are—(1) it is impossible to probe the swollen and inflamed duct without injuring the walls , (2) such injury may lead to infection of the surrounding tissues and an acute cellulitis , (3) in any case healing of the abrasions is accompanied by the formation of connective tissue, which contracts when it organises and leads to fibrous stricture instead of obstruction by swollen mucous membrane , (4) probing is always painful, and when once begun has to be continued for a prolonged period , (5) most cases are alleviated only temporarily, fresh courses of probing being required at intervals Protargol should never be injected immediately after slitting up the canaliculus or probing If an abrasion of the mucous membrane has been caused the protargol may be injected into the subcutaneous tissues and violent cellulitis follows Orbital cellulitis and atrophy of the optic nerve have been known to result from neglect of this rule Even if these serious results do not follow there is unsightly and permanent staining of the skin These facts are proof of the injury done to the mucous membrane by probing
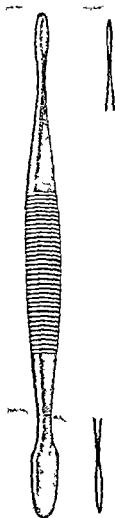
Fig 359 —Stella d s lacrymal dissector

Excision of the Lacrymal Sac (Dacryocystectomy) is performed as follows Instruments required Bard Parker knife

(No 15 blade), fixation forceps, Briggs's retractor (Fig 361), blunt dissector (Fig 362), blunt pointed conjunctival scissors, curette, 4 mosquito pressure forceps, 1 catgut 000,000 ligature and 1 suture, 1 gossamer horse hair suture on eyeless needle, 1 No 1 white silk suture, needle holder, 2 small claw retractors, canaliculus rasp, punctum dilator, Couper's lacrymal probes, and lacrymal syringe

The operation can be performed with local anæsthesia Four drops of pantocain (1 per cent) are instilled and novutox
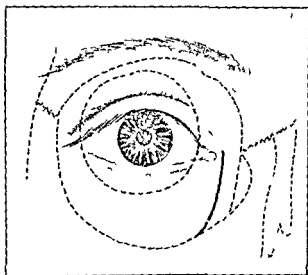
Fig 363 —Incision for excision of the lacrymal sac   The broken lines indicate the bones and orbital margin , also the limits of the con junctival sac

(2 per cent) with adrenaline is injected through the skin just above the fundus of the sac and along the upper canaliculus   A second injection is made along the lacrymal crest over the sac, and is carried deeply along the floor of the orbit where the sac joins the nasal duct   It is also necessary to inject 3 minims of novutox into the skin of each lid 3 mm from the centre of the lid margin   The ipsilateral nasal fossa is sprayed with cocaine and adrenaline, and may be packed with ribbon gauze soaked in an oily solution of the same drugs

The canaliculi are fully dilated, and the lacrymal sac irri gated with warm saline   Five minims of sterile melted wax

impregnated with methylene blue may be injected so as to assist in the identification of the sac. The lids are temporarily closed with mattress sutures passed through the skin 3 mm. from the centre of the lid margins in order to avoid the danger of an infected abrasion.

An assistant stretches the skin by moderate traction with one finger at the outer canthus and the other on the bridge of
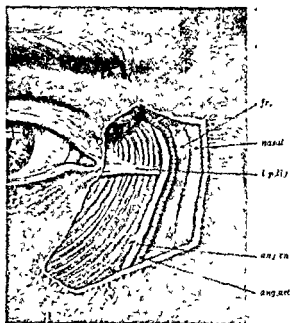
Fig 364 —Relations of angular artery and vein. *ang art*, angular artery , *ang vn* , angular vein ; *i p lig* , internal palpebral ligament ; *nasl*, nasal bone ; *fr* , frontal process of superior maxilla (Eugene Wolff " Anatomy of the Eye and Orbit " Lewis, London)

the nose A curved incision is made, beginning 2 mm. above the medial palpebral ligament and 3 mm. to the nasal side of the inner canthus ; it is carried vertically downwards for 4 mm., and then outwards along the line of the anterior lacrymal crest to a spot 2 mm. below the inferior orbital margin. The skin of the temporal edge of the incision is undermined for 2 or 3 mm , but not that of the nasal edge, owing to risk of wounding the angular vein or its branches. The orbiculari^ is split in the line of the incision, and Briggs's retractor inserted so as to retract it with the skin. The lacrymal

fascia is exposed and incised along the anterior lacrymal crest, thus bringing the bluish sac into view. This is freed from the bone on the nasal side by the blunt dissector (Fig. 362) and from the palpebral ligament, &c., by careful dissection until it remains attached only below to the nasal duct. The sac is drawn forwards and twisted two or three times in pressure forceps until it tears away from the duct. The upper end of the duct is curetted, and a Couper's probe passed down into the nose. The lids are now released and the epithelium
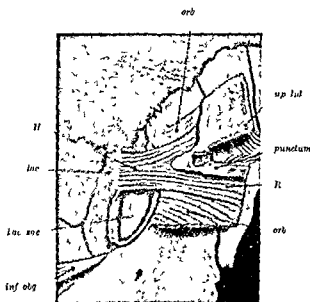
Fig 363.—Lacrymal sac. *H*, Horner's muscle ; *lac*, lacrymal bone ; *lac sac*, lacrymal sac ; *inf obq*, inferior oblique ; *orb*, orbicularis. (Eugene Wolff "Anatomy of the Eye and Orbit" Lewis, London)

lining the canaliculi removed by a canaliculus rasp. The orbicularis is sutured with catgut, and the skin incision by a continuous subcuticular suture. The eye is irrigated with oxycyanide of mercury (1 in 10,000) and a drop of mercurochrome (1 per cent) instilled A pyramid-shaped gauze dressing, with its apex against the wound is applied firmly.

Dacryocystorhinostomy is a more difficult operation, and is only suitable for cases of young or middle-aged adults with dacryocystitis of comparatively recent origin The early steps of the operation are the same as for excision of the sac. An opening is

then made through the lacrymal bone into the nose   The nasal
mucosa is freed and the lacrymal sac incised so as to fashion
two panels   Fig 367 shows the suturing of the posterior panels
The anterior panels are similarly sutured, thus covering the bony
aperture with mucous membrane   When successful this operation
restores a quasi normal excretion of the tears into the nose, but
in many cases the opening from the sac through the bone into
the nose becomes blocked with granulation tissue

There is no objection to removing both lacrymal sacs at the
same operation if there is bilateral mucocele   When the
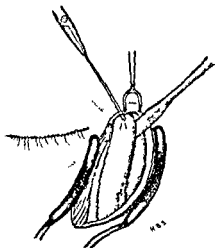
Fig 366

operation is satisfactorily performed there is no regurgitation
on pressure over the scar   If after a week or two there is still
some regurgitation, part of the mucous membrane has been
left behind, and the operation must be repeated   Usually it
is the fundus of the sac which has been left   This lies above
the palpebral ligament ; hence the advisability of dividing the
ligament in some cases in order that a good view may be
obtained   Sometimes regurgitation is due to leaving the
mucous membrane of the upper part of the nasal duct ; it will
not occur if the duct is well curetted

In all cases of cataract in which there is a mucocele the
lacrymal sac should be excised as a preliminary to extraction

Only some weeks after this operation when there is no trace of regurgitation is it permissible to proceed with the extraction. A more difficult problem is the presence of a mucocele in a case of acute glaucoma. Here immediate iridectomy may be indicated and admits of no delay. In these cases the sac must be completely isolated from the conjunctival sac. This is best effected by passing a ligature round each canaliculus and tying it firmly. Some surgeons cauterise the punctum, thus sealing it up with a cicatrix. Either procedure may be followed by the development of a lacrimal abscess but in the meantime the iridectomy wound has probably healed and in any case the pus is evacuated through the skin and not into the conjunctival sac.
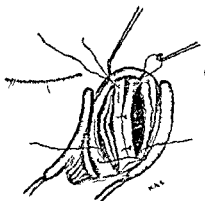
FIG 367

Epiphora usually persists for a time after excision of the sac. This is due to the chronic conjunctivitis set up by the mucocele since as already stated (p 647) under normal conditions the tears evaporate from the surface of the globe. Hence the post-operative epiphora should be treated by astringent lotions &c, in no case is it necessary in my *experience to remove the lacrimal gland* as has been advocated. Epiphora will however still occur on exposure to wind &c and this cannot be avoided.

Lacrimal Abscess may be due to acute dacryocystitis or to suppuration starting in the pericystic tissues. The skin over the sac becomes red and swollen. The redness and swelling rapidly extend to the lower lid and upper part of the cheek, so that the condition may be easily mistaken for

erysipelas   There is severe pain, and often some fever   The abscess usually points below and to the outer side of the sac owing to gravitation of the pus to the margin of the orbit   If it opens spontaneously pus continues to be discharged for some time, and a permanent fistula is likely to result

Treatment   If seen at the beginning of the process an attempt may be made to draw the contents of the sac into the nose by cocaining the ipsilateral nasal fossa and inserting a tampon soaked in adrenaline (1 in 2,000) over the opening of the nasal lacrymal duct   An injection of 5 minims of adrena line (1 in 2,000) is made into the lacrymal sac   In some early cases the muco pus can then be coaxed down the nasal duct

Hot bathing should be persevered with and incision should not be resorted to unless the abscess is pointing under the skin, in which case it should be opened by a small incision, the pus gently squeezed out, a piece of rubber glove drain inserted, and a magnesium sulphate and glycerine dressing applied

If the discharge continues for a long period the cavity should be well curetted and again drained   Sometimes the epithelial lining of the sac is destroyed by the purulent inflammation, the sac is permanently destroyed, and the cure is complete   In other cases some of the mucous membrane escapes destruction, and a fistula may follow   It may some times be closed by cauterising the edges with the galvano cautery, but it is better to re open the sac along a director introduced through the fistula and extirpate the remnants This procedure should not be adopted until several weeks after the acute inflammation has subsided

Stricture of the Nasal Duct has already been referred to incidentally   It is probable that most intractable fibrous strictures are caused by probing, though it cannot be asseve rated that they may not arise spontaneously as the result of destruction of the epithelium by extension of inflammation from the nose or lacrymal sac   Occasionally bony strictures occur, usually caused by fractured maxilla, inflammation of the antrum, or caries

Treatment   The usual treatment of stricture of the nasal duct is dilatation with probes   The objections to this treat ment have been mentioned   I advocate excision of the lacrymal sac in these cases

CHAPTER XXXIII

Diseases of the Orbit

It is unnecessary to describe the anatomy of the orbit and its contents here   The student is recommended to revise his knowledge of the subject, paying special attention to the relations of the nasal cavities and their accessory sinuses, and to the communications with the interior of the cranial cavity by way of the optic foramen and sphenoidal fissure   The intimate adhesion of the dural sheath of the optic nerve to the walls of the optic foramen is of great pathological importance, and the relations of the intraorbital to the intracranial circulation must be thoroughly appreciated   The eye is slung in position in the orbit by fascia, one sheet of which, Tenon's capsule, forms a socket in which the globe moves   This, with the sclerotic, forms a lymphatic space, lined completely with endothelium   The extrinsic muscles of the eye do not perforate this capsule, but invaginate it, the fascia being reflected from their surfaces

The normal position of the eye is such that a straight edge applied vertically to the middle of the upper and lower margins of the orbit just touches the closed lids over the apex of the cornea   There are individual variations which are of no pathological importance when symmetrical, in all cases of doubt the two sides should be compared

Abnormal protrusion of the globe is called *exophthalmos* (more accurately, *exophthalmia*) or *proptosis*   It is much commoner than abnormal retraction or *enophthalmos*   The former condition is due to many causes, among which increase in the orbital contents and loss of tone of the extrinsic ocular muscles are the most important   Slight prominence of the eyes accompanies high myopia, paralysis of the extrinsic muscles, stimulation of Müller's muscle by cocaine, and as an idiosyncrasy, especially in very obese people   Unilateral exophthalmos occurs in orbital cellulitis from any cause, thrombosis of the orbital veins with or without implication of the cavernous sinus, arterio-venous aneurysm, tumours of the orbit and its contents, and orbital hæmorrhage or

emphysema Bilateral proptosis occurs in exophthalmic goitre, the later stages of thrombosis of the cavernous sinus, empyema of the accessory sinuses of the nose, symmetrical orbital tumours (lymphoma, pseudoleukæmia), and as a result of diminished orbital volume in oxycephaly or "tower skull" and leontiasis ossium Enophthalmos is generally due to severe injury in which the orbital bones are fractured, or to orbital cellulitis with mechanical retraction by fibrous tissue Slight degrees of exophthalmos or enophthalmos are best diagnosed by the test with a straight-edge Accurate estimates of the amount can be obtained only by special mechanical devices (exophthalmometers) A convenient test is the following The patient is seated, the surgeon standing behind him The surgeon holds the patient's head in such a manner that he looks straight down the nose He then rotates the head backwards until he can just see the apex of one cornea If he can see more of the other cornea, that eye is relatively proptosed

ORBITAL INFLAMMATION

Periostitis is not uncommon, particularly affecting the margin It is most often due to injuries, extension of inflammation from neighbouring parts, tubercle or syphilis Tuberculous periostitis is most frequent in children, syphilitic in adults in the former, caries of the bone results, the latter is gummatous In traumatic cases the margin is naturally most affected, but a traumatic element is often an exciting cause in the other cases, so that in them also the margin most frequently suffers

When situated at the margin, the inflamed part is swollen and tender, the swelling is intimately connected with the bone, so that it cannot be moved over it Syphilitic cases usually respond well to treatment The other types generally go on to suppuration An abscess is formed, and when it discharges or is opened rough bone can be felt with a probe In tuberculous cases particularly a fistula may result, the edges of the aperture being bound down to the bone, so that a depressed cicatrix is formed The fistula remains open until all the necrosed bone is extruded The cicatrisation may lead to displacement of the lid—ectropion, lagophthalmia, and so on.

Periostitis of the deeper parts of the orbit causes less definite signs There is more pain of a deep-seated character. There may be proptosis with deviation in the direction of the

eye In the case of gumma the roof of the orbit is generally involved, the deviation of the eye is downwards, and there is rapid loss of movement owing to involvement of the extrinsic muscles There is severe supraorbital neuralgia, which is worse at night Often the true nature of the disease is only discovered by an exploratory operation, or by the evacuation of pus The case may present all the features of orbital cellulitis (*q v*) If the roof of the orbit is involved the pus may discharge into the cranial cavity, life being endangered by meningitis or cerebral abscess

Treatment is determined by the ætiological factor In syphilitic cases, mercury and iodide of potassium are pushed rapidly In traumatic cases, if suppuration supervenes, the abscess is opened, hot fomentations being applied previously if necessary In tuberculous cases an incision should be made early and any carious bone removed, care being taken not to encroach upon the cranial cavity

In deep seated periostitis an exploratory operation may be necessary, and should not be too long delayed An incision is made through the skin at the margin of the orbit, the knife being passed cautiously deep into the orbit along the wall The site of the incision is determined by the signs present Sinus forceps are passed down the track of the wound and opened The greatest care should be exercised to avoid unnecessary damage to the orbital contents, and this is best accomplished by keeping closely to the bony walls Special care must be taken not to injure the pulley of the superior oblique If pus is found, a small drainage tube or a strip of rubber glove or cyanide gauze is inserted In periostitis of the inner wall, the bone may be extensively diseased Severe operations, involving the opening of the frontal or ethmoid sinuses, may be essential, with or without drainage through the nose These cases often do remarkably well They are usually tuberculous, and occur most frequently in children Exploration of the orbit in children is much more difficult than in adults The eye is relatively much larger in comparison with the size of the orbit, so that there is very little room between the globe and the orbital wall In rare cases it may be advisable to perform Kronlein's operation (*vide* p 673)

Orbital Cellulitis is purulent inflammation of the cellular tissue of the orbit It is due to deep injuries, especially those with retained foreign body, or septic operations, *e g*, enucleation of the eyeball, extension of inflammation from neigh-

bouring parts, especially the nasal sinuses and teeth, facial erysipelas, metastasis in pyæmia, meningitis, infective fevers, &c

There is great swelling of the lids, with chemosis   The eye is proptosed, and its mobility impaired   Pain is severe, increased by movement of the eye or pressure upon it   Fever is present, and cerebral symptoms may arise   Movement of the eye is painful, and there may be diplopia owing to limitation of movement   Vision may not be affected, or it may be reduced owing to retrobulbar neuritis   The fundus is difficult to examine   it may be normal or show engorgement of the veins and optic neuritis, passing later into optic atrophy   An abscess is formed which usually points somewhere in the skin of the lids near the orbital margin, or it may empty into the fornix conjunctivæ   Panophthalmitis may supervene.   There is grave danger of extension to the meninges and brain, leading to a fatal issue from purulent meningitis or cerebral abscess   Thrombosis of the cavernous sinus ($q\,v$) may result from orbital cellulitis, and is always difficult to diagnose from it

Treatment   Hot bathings, and medical diathermy, if available, are applied, but must not be relied upon too long   An early incision as in orbital periostitis ($q\,v$) is imperative   Even if pus is not reached, the tension is relieved and a track is prepared for its evacuation   If the source of infection is obscure   the nose and other likely seats must be investigated, and the primary focus treated   The administration of sulphonamides by the mouth may be helpful

Thrombosis of the Cavernous Sinus may be due to extension of thrombosis from various sources

The anatomy of the venous channels which communicate with the cavernous sinus is of prime importance for the comprehension of thrombosis affecting it (Figs 368, 369)   The superior and inferior ophthalmic veins enter it in front and the superior and inferior petrosal sinuses leave it behind   It communicates directly with the pterygoid plexus through the middle meningeal veins and the vein of Vesalius, and indirectly through a communicating vein from the inferior ophthalmic to the pterygoid plexus   The anastomoses of the ophthalmic veins with the frontal and angular open up a communication with the face   Labyrinthine veins opening into the inferior petrosal sinus afford a communication with the middle ear   Numerous tributaries throw it into direct or indirect communication with most parts of the cerebrum   The mastoid emissary vein places the sinus in communication

with the subcutaneous tissues behind the ear through the lateral sinus and superior petrosal sinus, it is this communication which is of great diagnostic importance, since swelling behind the ear may decide the question of thrombosis in each direction along them The sinus of one side communicates with that of the other by two (or sometimes three) transverse sinuses which surround the pituitary body

Infection may occur *via* the orbital veins—*e g*, erysipelas and septic wounds of the face, orbital cellulitis, and mouth and pharynx, from the ear, nose and accessory sinuses, or as a metastasis in infectious diseases or septic conditions

The patient presents almost the same symptoms and signs as in orbital cellulitis If in addition there is œdema in the
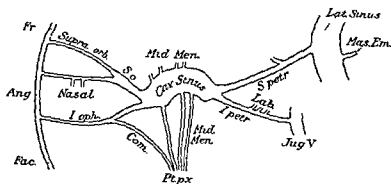
Fig 368.—Tributaries of the cavernous sinus (lateral view)

mastoid region behind the ear the diagnosis is certain, for this is due to thrombosis of the emissary vein A further point of diagnostic importance is transference of the symptoms to the opposite eye, which occurs in 50 per cent of cases, whereas bilateral orbital cellulitis is very rare The first sign is paralysis of the opposite external rectus, and this sign should be carefully watched for in any suspicious case of inflammatory unilateral exophthalmos It must be remembered, however, that thrombosis of the sinus may be a complication of cellulitis

There is severe supraorbital pain, owing to implication of the branches of the ophthalmic division of the fifth nerve, and the motor ocular nerves are paresed or paralysed In the later stages the eye is immobile, the pupil dilated, and the cornea anæsthetic Proptosis occurs in nearly all cases, but is of late onset in those of otitic origin

It is commonly stated that the retinal veins are greatly engorged, but in many cases this is certainly not true When it occurs it is usually accompanied by pronounced papillitis and both signs indicate extensive implication of the orbital veins and tissues Simultaneous thrombosis of both cavernous sinuses with proptosis and papillitis occurs in diseases of the sphenoidal sinuses Typical papilloedema is commonest in otitic cases and indicates meningitis or cerebral abscess it is bilateral and more pronounced on the side of the aural lesion

Thrombosis of the cavernous sinus is accompanied by
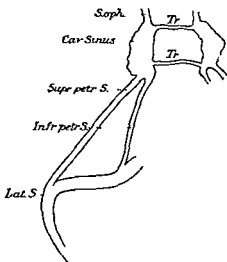
FIG 369 —Tributaries of the cavernous sinus (from above)

rigors vomiting and severe cerebral symptoms The patient almost invariably dies Sulphonamides and heparin injections should be tried

Tenonitis is inflammation of Tenon's capsule it may be serous or purulent There is exophthalmos straight forward, with limitation of movement of the globe and pain on attempted movement There may be some œdema of the lids, and chemosis It may occur in severe iridocyclitis, and is constant in panophthalmitis It may also follow tenotomy, &c Simple serous tenonitis is rare, and has been attributed to influenza gout rheumatism &c

Treatment consists in the application of hot bathings and the evacuation of pus, if it forms The appropriate sulphona

mide should be used according to the bacterial agent at work (*vide* p 693) When it occurs as part of panophthalmitis, &c, it requires no special treatment

DISTENSION OF THE ACCESSORY SINUSES OF THE NOSE

The accessory sinuses of the nose—the frontal, ethmoidal and sphenoidal sinuses, and the antrum of the superior maxilla—are separated from the orbit only by thin plates of bone The orifices which form the communication between these cavities and the nose are liable to become occluded by catarrh,

FIG 370—Distension of the frontal sinus

polypi, neoplasms &c The normal sero mucous discharge is thus unable to drain into the nose The cavities become distended with fluid and owing to the presence of pyogenic organisms pus may be formed The treatment of the conditions thus set up cannot be considered part of the functions of the ophthalmic surgeon, but he must be prepared to diagnose them since they not infrequently appear for the first time in the ophthalmic clinic This is particularly the case in distension of the frontal ethmoidal and sphenoidal sinuses Of these the frontal sinus suffers most often

Distension or empyema of the frontal sinus causes bulging at the upper and inner part of the orbit (Fig 370) There may be some proptosis and displacement of the eyeball downwards and outwards but these features are more marked when the

ethmoidal sinus is involved. Œdema of the upper lid or slight ptosis may be the only external sign. There is considerable pain and tenderness, with severe headache. There is often discharge from the nostril of the same side, or manifest disease of the nasal cavities. Owing to erosion of the walls of the sinus the fluid may extend under the periosteum, causing bulging into the posterior part of the orbit. It may escape into the opposite sinus and through the infundibulum of that side, or it may rupture into the orbit, through the skin, forming a sinus, or even into the cranial cavity. Orbital cellulitis may be set up in this manner.

The frontal sinus is not developed until about the sixth year, the disease occurs most commonly between twenty five and thirty, and more cases occur in men than in women.

Treatment of distended frontal sinus consists in providing free discharge of the contents through the nose. In most cases a radical cure is effected only by laying open the sinus, scraping away completely the diseased mucous membrane, and passing a drain down into the nose. The disease is tedious to treat and much disfigurement may follow. Displacement of the pulley of the superior oblique may lead to diplopia, which may persist for several months or permanently.

Distension of the ethmoidal cells by polypi, new growths or inflammatory products may also cause bulging into the orbit and displacement of the globe. Diplopia, chemosis, venous engorgement and ptosis may be caused. Ethmoiditis is usually associated with nasal discharge. It may give rise to orbital cellulitis, or in less severe cases to retrobulbar neuritis. The latter is probably more commonly associated with inflammation and distension of the sphenoidal cells, which lie in close proximity to the optic nerve being sometimes separated from it by a very thin lamina of bone. In doubtful cases help may be afforded by a skiagram. It has already been mentioned that the accessory sinuses of the nose are not infrequently the foci from which toxins are disseminated, leading to iridocyclitis and other metastatic septic processes in the eye (vide pp 273, 341).

INJURIES OF THE ORBIT

Injuries to the soft parts usually arise from penetration of a foreign body, which may be retained. The lids and eyeball are frequently implicated. The signs depend upon the particular structures injured. In most cases there is considerable

hæmorrhage, as the blood does not find a ready exit exophthalmos may result. Extravasation of blood under the conjunctiva and into the lids is common. Hæmorrhage may result from pressure with forceps at birth. It also occurs in some cases of fracture of the base of the skull. Paralysis of extrinsic muscles may be due to direct injury or to injury of the motor nerves. The optic nerve may be severed or retrobulbar neuritis may ensue. in either case atrophy involving the optic disc, follows (*vide* p 399) or atrophy may follow hæmorrhage into the sheath of the nerve. The nerve may be divided either posterior to or rarely, anterior to the entrance of the central retinal vessels. Avulsion of the disc with the formation of a traumatic 'coloboma' or "conus" of the disc may occur even without rupture of the sheath of the nerve. The eyeball may be perforated or contused (*vide* p 432) or dislocated *en masse*. Dislocation forwards between the lids occurs most often when the blow is directed from the outer side, where the orbital margin affords least protection. Insane patients sometimes enucleate their eyes by gouging them out with their fingers. Sight is not necessarily lost after dislocation forwards. Retained foreign bodies are extremely liable to set up suppuration and orbital cellulitis (*q v*)

Injuries to the bone most commonly affect the margin of the orbit. Fractures in this locality are easy to diagnose from the unevenness of the margin sensitiveness to pressure, and sometimes crepitation. Emphysema (*q v*) may occur. The soft parts may be injured by splinters of fractured bones. Deep fractures may be caused by penetrating wounds or by severe contusions falls, &c. Fracture of the base of the skull may involve one or both optic foramina in which case the optic nerve is often severed lacerated or compressed by clot, or pulsating exophthalmos (*q v*) may ensue. Blindness without ophthalmoscopic signs may be caused in this manner, atrophy of the disc follows in three to six weeks (*vide* p 401)

Gunshot wounds of the orbit, without direct involvement of the eye, frequently produce concussion changes which appear ophthalmoscopically as coarse tracks of white exudate in the retina and choroid large blot like hæmorrhages, and multiple small choroidal tears. These resolve into dense white scarred areas fringed with pigment with finer pigmentary disturbance elsewhere in the fundus. The site may give an indication of the direction of the track of the missile and assist in localising a retained intracranial foreign body. Both eyes should be examined, as the missile may have traversed both orbits

Treatment If there is a wound it must be cleansed and, if necessary probed it should be dusted with sulphonamide Absorption of extravasated blood is often very slow The treatment of a retained foreign body depends upon its situation and the probability of suppuration occurring If the foreign body cannot be extracted with ease a skiagram should be taken If the position is such that very serious manipulation would be requisite for removal and if there is evidence that the substance is aseptic, expectant treatment may be adopted If suppuration occurs the foreign body must be removed and the case treated as one of orbital cellulitis ($q v$)

TUMOURS OF THE ORBIT

Orbital tumours are rare Benign growths include dermoid cyst dermo lipoma (*vide* p 195) angioma osteoma (Fig 371) plexiform neuroma (*vide* p 645) meningo encephalocele Of these dermoid cysts appear as swellings under the lid usually at the upper and outer angle, they contain sebaceous material derived from sebaceous glands in the walls, which are lined

with epithelium and possess hair follicles, they sometimes contain foetal remnants (teratoid cysts) Clinically they may be mistaken for meningo encephaloceles which usually occur at the upper and inner angle, where there are most sutures between bones In the latter—
(1) the tumour is immovably attached to the bones, (2) the hole in the bone may be palpable, (3) pulsation, synchronous with respiration and the pulse and increasing on straining, can be seen (1) pressure

FIG 371—Orbital osteoma (Tweedy)

may cause diminution in size due to fluid being pressed back into the cranium, (5) exploratory puncture produces clear fluid with the characteristics of cerebro spinal fluid Osteomata start usually from the frontal bone (Fig 371),

they are intensely hard and often large producing great
displacement of the globe

Malignant tumours of the orbit are usually sarcomata though
carcinoma derived from the lacrymal gland (*vide* p 648) or
by extension from the nasal mucous membrane also occurs
All types of sarcoma including endothelioma and myeloid
sarcoma may occur The small round celled growths include
cases of lymphoma leukæmic tumours chloroma &c

Primary tumours of the optic nerve manifest themselves
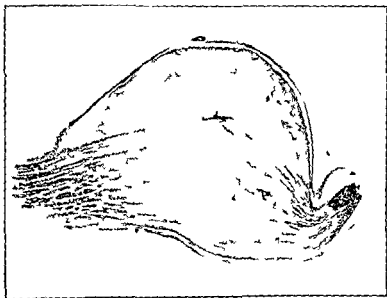
Fig 372—Intradural tumour of the optic nerve (Mayou) Longitu
dinal section on section on staned by Weigert Pal to show distribution of
the nerve fibres

clinically as orbital tumours They are rare and are found on
anatomical examination to consist of two groups—intra and
extradural Of these the former are more numerous (Fig 372)
They rarely spring from the true nervous tissue (gliomata
resembling cerebral glioma not retinal glioma) but usually
originate in the connective tissue septa derived from the pia
mater and from the arachnoid sheath (meningiomata) They
often contain tissue of mucoid type and are hence described
as myxo sarcoma &c Probably most are endotheliomata
which have undergone degenerative changes Extradural
fibromata and fibro sarcomata spring from the dural sheath

(Fig 373) All these optic nerve tumours are most common in children and are locally malignant, but show little or no tendency to metastasis They may kill the patient by intra cranial extension

Most orbital tumours cause proptosis, which is very rarely straight forwards except in the case of optic nerve tumours This is an important diagnostic feature The exophthalmos increases slowly and gradually, and is nearly always unilateral in rare cases of lymphoma it is bilateral The mobility of the eyeball is impaired in the direction towards the position of the tumour There is usually diplopia from this cause Papillitis may be present, especially with optic nerve tumours Optic atrophy from pressure on the nerve is common in the other forms The tumour may be palpable by the finger pushed back between the globe and the orbital wall The lymphatic glands are seldom affected

Careful examination of neighbouring parts—nose, antrum, mouth (especially the naso pharynx, and line of the teeth)—must be made to determine whether the invasion of the orbit is secondary or whether the growth is primarily orbital In doubtful cases an X ray examination should be made
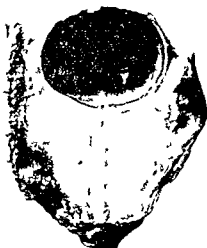
Fig 373—Extradural tumour of the optic nerve (× 1 4)

Treatment An exploratory operation and removal of a portion of the growth for microscopic examination may be a necessary preliminary to radical treatment It may be feasible to remove dermoid cysts and some other benign tumours without injury to the globe, though its mobility is likely to be impaired in extensive operations As already mentioned, many malignant orbital growths show little tendency to metastasis, so that their treatment may be more conservative than is usual in other parts of the body Thus it is possible in some cases of optic nerve tumour to remove the growth while retaining the eyeball This can be effected by

Krönlein's operation, which is also of utility as an exploratory procedure in some cases In it a semilunar incision is made vertically just outside the outer canthus, the convexity being directed forwards The bone is chiselled through at the upper and lower outer angles of the orbit, and bone, muscle and skin are reflected backwards in one flap The posterior part of the orbit is thus exposed in a manner which is impossible by any other method The greatest care must be exercised that infection does not occur, since the spongy bone is laid open, and there is also danger of meningitis

In the case of more malignant types of tumour their complete removal is imperative at all costs, and the eye, which may be quite normal, may have to be sacrificed In these cases, as well as in recurrence or in orbital extension of malignant intraocular growths (glioma of the retina, sarcoma of the uveal tract) it may be necessary to remove the whole contents of the orbit

In *exenteration of the orbit* the lids may be retained if they are not implicated in the growth, but the free margins, carrying the cilia, should always be removed If it is not done the lashes are troublesome when the lids become retracted into the orbit, as invariably follows If the lids are removed the incision is carried through the skin at the margin of the orbit in its whole circumference The orbital contents are separated from the walls by a periosteal elevator, so that they remain attached only at the apex of the orbit The pedicle is then severed with strong scissors, or preferably by diathermy, thus avoiding haemorrhage At a later stage it may be advisable to apply Thiersch grafts to the walls, since the lids and conjunctiva never afford sufficient epithelial covering, and the extension of the epithelium over so large a surface is a tedious process

Some of these tumours respond to irradiation and radium treatment by shrinking, but the ultimate results are usually disappointing Recurrence in the orbit should, however, be treated by these means

Special Forms of Exophthalmos

Exophthalmic Goitre (Syns —*Graves's or Basedow's Disease*) is one of the commonest causes of exophthalmos (Fig 374) The symptom complex includes, besides proptosis, enlargement of the thyroid gland, tachycardia, muscular tremors, and raised basal metabolism The proptosis is almost always

bilateral and may be extreme, leading to lagophthalmia and its deleterious consequences (*vide* p. 225). There is a peculiar stare, with retraction of the upper eyelid, so that there is an unnatural degree of separation between the margin of the two lids (Dalrymple's sign). Normally, when vision is directed downwards, the upper lid moves concordantly with it. In this disease the upper lid follows tardily or not at all (von Graefe's sign): this symptom is not always present and may occur in other forms of exophthalmos. There is diminished frequency of winking and imperfect closure of the lids during the act (Stellwag's sign). There may be imperfect power of

Fig 374.—Exophthalmic goitre.

convergence (Möbius' sign), and often the skin of the eyelids shows pigmentation. Ophthalmoscopically veins and arteries may be somewhat distended, but specific signs are absent. One or more of the cardinal symptoms may be absent. The eye may become dislocated forwards between the lids, the orbicularis contracting in spasm behind it. Reduction is effected by separating the lids and bringing them forwards over the eye, if necessary after blocking the facial nerve with novocain.

The chief cause of the disease appears to be overproduction of thyroid secretion of an abnormal type combined with over-activity of the anterior lobe of the pituitary gland. The exophthalmos is said to be due to the latter cause, and not to

be produced by over treatment with thyroid extracts or thyroid hormone

Paralysis of extrinsic ocular muscles, usually the external rectus, sometimes precedes the protrusion of the eyes (*exophthalmic ophthalmoplegia*) In these cases thyrotoxicosis seems to be absent, since the thyroid is not generally enlarged and basal metabolism is normal or subnormal The disorder sometimes comes on after partial thyroidectomy and may be aggravated by injections of thyrotropic pituitary hormone The disease is progressive diplopia persists, and the muscles may be pale, œdematous and swollen to six times their normal size More benign cases of ptosis associated with exophthalmos, however also occur

It is necessary for the ophthalmic surgeon to be able to recognise the disease Further details of its usual course and treatment must be sought in medical text-books

Pulsating Exophthalmos is generally due to arterio venous aneurysm, the communication taking place between the internal carotid artery and the cavernous sinus The eyeball is protruded and the blood vessels of the conjunctiva and lids are widely dilated The angular vein and its branches near the inner canthus are very prominent, and they can be seen, or more easily felt, to pulsate synchronously with the arterial pulse, since, owing to the arterio venous communication, they are under arterial pressure The patient complains of continual rumbling, as of a waterfall, and this can be heard on auscultation over the eye or orbit by the surgeon The proptosis is diminished by steady pressure on the globe, and may be diminished or abrogated by pressure on the common carotid artery of the same side or sometimes only by pressure on the carotid of the opposite side Ophthalmoscopically the veins of the retina are greatly distended there may be papillitis with defective vision, which may amount to complete blindness There is often considerable pain from stretching of the branches of the fifth nerve

The cause of the arterio venous aneurysm is usually a severe blow or fall upon the head, and is therefore commoner in men, but probably in all cases the walls of the artery are already degenerated It may occur from syphilitic or other arteriosclerosis, without discoverable traumatism, especially when it occurs in women The exophthalmos in rare cases subsides spontaneously More commonly it increases, and may end in hæmorrhage or death from cerebral causes

Treatment Continuous pressure applied to the carotid

artery which stops the pulsation usually fails to effect a cure
Ligature of the carotid has been more successful but recur
rence of pulsation not infrequently occurs   Ligature of both
internal and external carotid does not appear to give better
results   The opposite carotid may also be tied but this should
not be done for some weeks after the first operation owing to
risk to life from cerebral anæmia   This procedure also may
fail to relieve the condition and in these cases the distended
veins have been dissected out an operation of considerable
danger

Intermittent Exophthalmos occasionally occurs generally
when the head is depressed enophthalmos not infrequently
being present in the erect position   The proptosis is increased
by pressure on the corresponding jugular vein   It is ascribed
to varicosity of the orbital veins

SECTION VIII

PREVENTIVE OPHTHALMOLOGY

CHAPTER XXXIV

The Causes and Prevention of Blindness

THE previous chapters have dealt chiefly with the diagnosis and treatment of already established diseases of the eye   An equally important branch of medical science is concerned with the prevention of disease, and although this aspect of ophthalmology has hitherto received less attention than it merits, it ought not to be ignored by the medical student or practitioner

The most disastrous result of ocular disease, short of the relatively rare loss of life, is blindness. A study of the causes of blindness will enable the student to form a judgment as to the comparative danger of various ocular diseases

The term " blindness " implies inability to perceive light ; but it is obvious that many people who yet retain some slight degree of visual capacity are helpless from the economic standpoint   The Advisory Committee on the Welfare of the Blind, therefore, included among the blind all those who are " too blind to perform work for which eyesight is essential " The Register of the Blind for England and Wales, compiled on this basis, shows that there were 67 521 blind persons in those areas in 1935, and 8298 in Scotland in 1934   Some 70 per cent of the total blind population are over the age of fifty, and 80 per cent of blind persons are unemployable

The factors producing blindness have a different rate of incidence at different ages   Thus, in a home for blind *infants*, Harman found about 50 per cent due to ophthalmia neonatorum, 11 per cent. to intraocular inflammations, and 30 per cent to congenital defects   Statistics of *children of school age* show that 20—30 per cent were blind from ophthalmia neonatorum, 10—20 per cent from interstitial keratitis, and 15—20 per cent had optic atrophy due to various causes, including disseminated choroiditis   The statistics for *adults* are very unreliable, owing to defective case histories, the impossibility in many cases of determining the causes of blindness from examination of the patients, and other

reasons   In middle life the high incidence of ophthalmia neona-
torum is still noticeable, choroiditis and optic atrophy are impor-
tant, while iritis and iridocyclitis are markedly advanced in
relative position   Many of these are symptomatic conditions,
the underlying cause being often syphilis   Myopia is a prominent
factor, accidents assume a high proportion, and glaucoma appears
increasing considerably in later life

The importance of *ophthalmia neonatorum* as a cause of blindness
is so great that it has been deemed advisable to discuss the
measures for its prevention earlier in this book (*see* p 161)
While there is unfortunately little evidence of any reduction in
the incidence of this disease in recent years there is some evidence
of a reduction in the amount of blindness caused by it.

Syphilis, both in the congenital and in the acquired form, is
responsible for a large amount of blindness   Harman found
definite signs of congenital syphilis in one third of a group of
1,855 blind children, and in most of these cases congenital syphilis
was the undoubted cause of the blindness   At least 10—15 per
cent of cases of blindness in adults are probably due to syphilis,
and these figures do not include cases due to vascular disease of
possible syphilitic origin

Phlyctenular keratitis was found to be the cause of blindness
in 3 56 per cent of 1,855 blind children (Harman)   This disease
and such conditions as blepharo-conjunctivitis are largely due to
insanitary conditions of life   They might probably be eliminated
as causes of blindness by the adequate provision for the education
and treatment of the children in special residential schools, a
method which has proved eminently successful for trachomatous
children   *Measles* is another not uncommon cause of blindness
through corneal ulceration , it emphasises the importance of
proper treatment of the eyes by the medical practitioner
Trachoma (*q v*) is, fortunately, now a rare cause of blindness in
this country

Myopia was the cause of blindness in 3 per cent of 1,855 blind
children (Harman), and in 14 per cent of 601 blind persons of all
ages (Harman)   These figures underestimate the serious distress
and economic loss due to this cause   It is generally agreed that
myopia is increased by near work (*vide* Chap XXIV)   Special
" myope " classes have been instituted for the education of short-
sighted children   " It is convenient to classify myopia in two
divisions— a ' school ' myopia and a ' pernicious ' myopia   The
former is, as a rule, low in degree, does not progress beyond a
certain extent, and is but rarely associated with other ocular
changes   The fact that ophthalmic surgeons recognise a school
myopia is the strongest argument for its prevention by the
provision of all those measures which are summed up in the term
' school hygiene ', such as good lighting in classrooms, good

print in books, regulated needlework, a maximum of oral instruction, and, above all, the early correction of errors of refraction and the special supervision of those who show signs of being or becoming short sighted But it is the pernicious myopia which figures in these tables of blindness or partial blindness—a variety which commences at an early age, may progress rapidly, is very liable to be associated with serious intraocular disease, and therefore necessitates the provision of special methods for the safe education of the subjects of it The cardinal aim should be to endeavour to prevent the continued development of the disease in the children affected, such prevention requires the complete elimination of any form of eye strain such as is involved in close work, and the provision of educational facilities under the best hygienic conditions, such as is aimed at in the myope classes ' There is evidence that habitual close eyework, such as that of clerks, sempstresses compositors &c , is disastrous to the eye sight of myopes, and every effort should be made to direct these people into suitable occupations

Glaucoma is a serious factor in the production of blindness after middle life , in a home for the aged blind the percentage of such cases was 29 82 'Cases of glaucoma frequently come in the first instance under the cognisance of the general practitioner The acute form is apt to be mistaken for iritis, with disastrous results if the treatment appropriate to this latter disease is adopted , on the other hand, as the disease is often ushered in by severe headache and vomiting, the essential ocular condition may be overlooked and the case regarded as a simple ' bilious attack ' The chronic form is so insidious in its onset that it may easily be overlooked It is unfortunately by no means rare to meet with cases of acute or chronic glaucoma which have been treated with atropine or allowed to progress without proper treatment It is of the utmost importance that the student should pay special attention to this disease and especially to the diagnostic features which distinguish it from iritis (*vide* p 260) If there is the slightest doubt as to the presence of glaucoma the case should be referred *immediately* to an ophthalmic surgeon

Industrial conditions may cause blindness, either by disease or accident The chief diseases, such as poisons (lead, derivatives of benzene, &c) glass- and iron workers' cataract, miners' nystagmus, &c , have already been dealt with Blindness due to industrial accidents is commonest among miners and in the engineering trades Of 5 575 blind persons of all ages the blindness was due to industrial accidents in 7 2 per cent (Scottish Register of the Blind, 1922) More striking is the enormous economic loss entailed by relatively minor accidents such as foreign bodies in the eye (*vide* p 427), &c Many of these could be entirely prevented by the use of appropriate guards, screens and goggles

These matters require special attention from factory medical
officers , but of far greater importance to the ordinary medical
practitioner is the grave risk of blindness due to sympathetic
ophthalmia produced by penetrating injuries of the eye   "The
danger of the development of sympathetic ophthalmia should
always be present in the mind of the medical practitioner, and all
cases of penetrating wounds of the eye should be placed imme
diately under the observation of an ophthalmic surgeon , in no eye
condition is prompt co-operation between the general practitioner
and the expert more essential "

(Further information and recommendations referring to the
subject of this chapter will be found in the Report of the Depart
mental Committee of the Ministry of Health on the Causes and
Prevention of Blindness   H.M. Stationery Office, 1922   and the
Report on the Prevention of Blindness, Union of Counties
Associations for the Blind, 1936)

CHAPTER XXXV

The Hygiene of Vision

APART from the conditions which seriously endanger the eye sight, discussed briefly in the last chapter, there are many others which are liable to impair the efficiency of vision or the health of the individual It is well known that the use of the eyes with uncorrected errors of refraction or muscle balance, or under unsuitable conditions of illumination, &c, cause ocular pain and discomfort (commonly known as 'eye strain"), headaches, migraine, and general malaise. More serious disorders and diseases have been attributed by some to these causes The exact pathology of "eye-strain" is unknown, and the *rationale* of visual fatigue in the production of ocular and systematic disorders is largely a matter of conjecture It is, in the first place, a safe principle to make the ametropic eye approximate by artificial means as nearly as possible to the emmetropic eye This is effected by suitable spectacles In the next place it is necessary to study the normal limits of adaptability of the eye to various conditions of illumination, &c, and to use the knowledge thus obtained to prevent these limits being transgressed When we bear in mind the evolution of the visual apparatus in man, and the immense increase in the amount and nature of the work which it is called upon to perform in modern civilised life, it is surprising that eyes are capable of withstanding the strain

Errors of Refraction The correction of ametropia by glasses has already been discussed It is evident that theoretically this correction should be made as early as possible, and especially before the increased strain of school life is encountered Much advance has been made in this direction in recent years, and the routine examination of the eyes of young school children ensures the discovery of serious errors Facilities for their correction and for the supply of suitable glasses are now prevalent The most difficult problem in this connection is that of myopia, which has already been dealt with in Chap XXXIV

Illumination Normal vision is capable of adaptation to very wide ranges of intensity and quality of illumination Form vision is very defective under dark adaptation and with low intensity of illumination As the intensity is increased and the eye becomes light adapted visual acuity increases—rapidly at first, and then

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Errors of Refraction. The correction of ametropia by glasses has already been discussed. It is evident that theoretically this correction should be made as early as possible, and especially before the increased strain of school life is encountered. Much advance has been made in this direction in recent years, and the routine examination of the eyes of young school children ensures the discovery of serious errors. Facilities for their correction and for the supply of suitable glasses are now prevalent. The most difficult problem in this connection is that of myopia, which has already been dealt with in Chap. XXXIV.

Illumination. Normal vision is capable of adaptation to very wide ranges of intensity and quality of illumination. Form vision is very defective under dark adaptation and with low intensity of illumination. As the intensity is increased and the eye becomes light adapted visual acuity increases—rapidly at first, and then

only very slowly The increase is proportional to the logarithm
of the intensity of the illumination, so that successive doublings
or treblings of the illumination cause only equal arithmetic
increments of visual acuity as estimated by the distance at
which a standard letter (1 25 mm square) can be read Above
10 foot-candles the increment becomes progressively less For
ordinary work an illumination of 5 foot-candles suffices, but for
fine work much higher values are desirable (vide p 684) At
extremely high illuminations, visual acuity is diminished owing
to glare It has been found that discrimination is increased by
using monochromatic light, chiefly owing to the elimination of
chromatic aberration in the eye, it is best with yellow light, the
brightest part of the photopic spectrum

There are many factors, however, which influence visual acuity
besides the intensity of the light Among these is the size of the
pupils, but more important is the amount and character of the
light falling upon peripheral areas of the retina Thus, it is
undesirable that there should be too great contrast between the
areas under observation and surrounding areas Thus, self
luminous figures with radio active paint are very difficult to focus
in complete darkness, especially in condition of fatigue A
brilliantly illuminated field of work in an otherwise dark room
causes rapid alterations of adaptation which are deleterious
Hence a moderate amount of general illumination is preferable,
and this has the additional advantage that it prevents the forma
tion of very sharply defined shadows On the other hand, it
is very important that there should be no glaring lights in the
field of vision, such lights should be carefully shaded Care,
too, should be taken to avoid direct reflection of light into the
eyes Thus, in reading, especially books written on shiny paper,
and in working on bright metals, &c , if the source of light is in
front of the eyes light is reflected directly into them This light
is useless for visual purposes, and indeed diminishes the contrasts
which are the basis of discrimination Hence the source of
light should be placed laterally, and preferably to the left hand
side and somewhat behind the worker Flickering lights should
be avoided

Various sources of light differ much in intensity and quality
The natural criterion is sunlight which we are accustomed to
regard as white light Sunlight differs much, however, in " white-
ness," and in intensity on different days, at different times of the
day, and whether direct or diffuse Owing to the adaptability of
the eye it is difficult to judge the intensity of a given illumina
tion Measurements show that bright direct sunlight may give
several thousand foot-candles, and an illumination of several
hundred foot-candles on a well placed desk is quite common One

great advantage of daylight is its diffusion, the illumination of a room usually comes, not directly from the sun, but from a considerable area of sky, and is reinforced by innumerable reflections from buildings and other objects Sunlight is much richer in luminous radiation of short wave length—blue and violet—than any artificial illuminants Most modern illuminants have continuous spectra derived from incandescent solids, the higher the temperature the more nearly the energy distribution of the spectrum approximates to that of sunlight An approximation to diffuse daylight for purposes of matching colours, etc, can be obtained by suitable filters ("daylight lamps") Incandescent gases—such as used in the mercury vapour lamp—have line spectra, they therefore more nearly approximate monochromatic light

Glare may be regarded as light in the wrong place The more concentrated the light the more disturbing is the effect Glare, therefore, varies rather with the intrinsic brilliancy of the light than with its intensity Intrinsic brilliancy is defined as candle power per square inch Clear sky has a very low intrinsic brilliancy —about the same as the candle, viz, 2 5 candles per square inch A metal filament has an intrinsic brilliancy of 800 c per square inch, and an arc light 20,000 c per square inch In general the ratio of the intrinsic brilliancy of a source of light to that of the surrounding field should not exceed 100 In general, the eye works best when the object regarded is surrounded by a field illuminated to the same or slightly less degree The illumination of the field must on no account be higher than that of the object Glare is diminished in artificial interior illumination by the use of indirect lighting In this method the light is reflected from the ceiling and suitably curved cornices, so that no direct light reaches the eye By it shadows are almost eliminated It is a restful, but monotonous mode of illumination, it is quite unsuited for certain purposes Thus, sewing is very difficult with it, especially the sewing of monochromatic material, because the threads of the texture throw no shadows, and consequently their discrimination is made very difficult In semi indirect lighting the use of opalescent bowls permits of a certain amount of direct illumination

Many modern illuminants emit a considerable amount of ultra violet radiation, which is deleterious (vide pp 188, 375) Most of this is absorbed by glass, so that the dangers arising from this cause are slight and have been much over rated It must be remembered, however, that globes absorb an appreciable amount of the luminous energy, even clear glass globes absorb 5—15 per cent, and opal globes as much as 10—40 per cent The distribution of light from artificial sources varies greatly It can be

modified by the use of reflectors and prismatic (holophane) globes
Too little attention has hitherto been paid by architects and
others to the position and characters of light sources from the
hygienic point of view. It is of great importance in the lighting
of factories and workshops, and especially in that of schools
There has been great improvement in the lighting of schools,
factories, shops, streets and houses of recent years, largely due
to the work of the Illuminating Engineering Society, which has
issued a schedule of Recommended Values of Illumination The
following list gives the general principles upon which they are
based :—

Recommended Foot-candle Value		Class of Task
1	Above 50	Precision work to a high degree of accuracy, tasks requiring rapid discrimination, displays
2	25—50	Severe and prolonged visual tasks, discrimination or inspection of fine details of low contrast
3	15—25	Prolonged critical visual tasks, such as proof reading fine assembling, and fine machine work
4	10—15	Visual tasks such as skilled benchwork, sustained reading and sewing on light goods
5	6—10	Less exacting visual tasks, such as casual reading and large assembly work
6	4—6	Work of simple character not involving close attention to fine detail
7	2—4	Casual observation where no specific work is performed

Reading and Writing Considering the vast importance of
reading and writing in modern life it is surprising that they have
been so little investigated by physiologists and ophthalmologists
The forms of printed types are derived from manuscripts, and
have been modified for technical reasons Further advance has
been almost entirely empirical and even in the best presses more
care has been exercised in obtaining æsthetic effects than in
fostering legibility

If we consider ordinary Roman printed characters we find that
all capital letters extend above the line Of the small letters
thirteen are short eight extend above the line (ascending letters),
and four below the line (descending letters) There are thus
twice as many ascending as descending letters and in an ordinary
page of print it will be found that of the long letters about 85 per
cent are ascending and only 15 per cent descending Examina
tion of the short letters shows that their most characteristic
features are in the upper parts Hence, in reading, attention is
specially directed to the upper parts of the letters, as is strikingly

demonstrated by covering the lower parts of a line of print with a card The print is almost as legible as if it were uncovered If, however, the upper halves of the letters are covered, it is almost, if not quite, impossible to read the print

The ends of the lines of which letters are composed are commonly emphasised by means of serifs These were doubtless introduced empirically, but the advantage in sharpness of definition has a physiological basis They counteract irradiation, and hence the visibility of letters is improved if the serifs are triangular

The tendency of typefounders has been to minimise the differences between letters, probably with a view to greater regularity of line and uniformity in appearance For example, round letters have been flattened laterally and square letters rounded The loops of b, d, p, and q, have been equalised to o If the lower parts of short letters are covered, the similarity in the topmost curves of a, c, e, o, s, of n and r, of h and b, or of n and p, is much greater in modern print than in some early samples

Legibility is not determined solely by visibility in the physiological sense of the term Thus, the emphasis of some lines in letters, which originated in the use of reeds and pens for writing increases legibility whilst diminishing visibility A child learning to read depends upon physiological visibility, hence there should be little difference between the breadth of the thick and slender strokes As facility in reading is acquired, legibility is increased by diminishing the breadth of the slender strokes and as smaller letters are used the diminution must be more rapid than that of the heavy strokes, so that the interspaces may not be unduly contracted At the same time, the slender strokes must not transgress the limits of visibility at reading distance, and their distribution should be emphasised by suitably formed serifs Hence, Jaeger small types are more legible than Snellen's

The spacing of the letters and words has a considerable effect upon legibility Irradiation plays an important part here Roughly speaking, the interspace between letters should be at least as broad as the blanks in m or n, but round letters like o and e should have slightly less interspace than square letters Owing to irradiation the interspaces in general look larger than they really are, and two o's separated by a space look farther apart than two n's separated by the same space Javal attributes a large part of the "remarkable legibility of English books" to the shortness of most English words and the consequent multiplication of blank interspaces Of course, the spacing of words, and to a less degree of letters in ordinary printing is very largely haphazard as far as legibility is concerned, the main object of the printer being to obtain general uniformity of

appearance with rigid equality in the lengths of the lines. There is some difference of opinion as to whether "leading" or interlinear spacing is beneficial. Owing to the design of the blocks of type there is always a small space between the lower limits of descending and the upper limits of ascending letters, even without leading.

A line of print is read in a series of small jumps. At each pause a group of about ten letters is more or less accurately visualised; the movements are too rapid to permit of visualisation whilst they are occurring. The number of leaps taken by the eye remains the same irrespective of the distance of the book, so long as this is consistent with legibility. A child reading makes more jumps in a line than the average, and the same applies to people reading a foreign language or correcting proofs. Attention is directed chiefly to the commencements of words, and words are not read by letters but by their general configuration. There is, therefore, a very important psychological factor involved in the act of reading, quite apart from the interpretation of the meaning of the words.

Enough has been said to show that reading is a highly complex act, and the rules which at present be devised for the avoidance of strain and discomfort involve a multiplicity of factors which have not yet been satisfactorily correlated.

Handicrafts. The same visual principles as have been discussed above underlie the carrying on of many handicrafts and industrial processes, but each provides specific problems. For some types of very fine work convex lenses bringing the near point to 8 or 9 inches from the eye, combined with appropriate prisms, bases in, magnify the retinal images and have been found to give much relief.

No attempt has been made in this Section to deal exhaustively with so extensive a subject as Preventive Ophthalmology, but it has been deemed advisable to indicate to the student how innumerable and complex are the applications of ophthalmology to everyday life.

APPENDIX I

PRELIMINARY INVESTIGATION OF THE PATIENT

SCIENTIFIC observation can only be fostered by methodical investigation The student is recommended to study each patient according to the following scheme —

(1) General condition of the patient

(2) Position of the head Characteristic in paralyses of extraocular muscles (*vide* p 553)

(3) Face Note asymmetry, facial paralysis, affections of the skin, e g , herpes ophthalmicus, &c

(4) Position of the eyebrows Vicarious action of the frontalis in ptosis (*vide* p 636), &c

(5) Orbits Exophthalmos, enophthalmos, &c

(6) Eyeballs (a) Position and direction—strabismus
  (b) Movements (*vide* p 519)
  (c) Size and shape—microphthalmia, glaucoma (*vide* p 283), myopia (*vide* p 518), buphthalmia (*vide* p 301) staphyloma, &c

(7) Lids (a) Position—ptosis, ectropion, entropion, &c
  (b) Palpebral aperture—ptosis, exophthalmos, &c
  (c) Movements—ptosis, exophthalmic goitre, &c
  (d) Margins—blepharitis, tumours, &c
  (e) Lashes—trichiasis, distichiasis, &c
  (f) Glands—hordeolum, chalazion, &c
  (g) Puncta lacrymalia—eversion, occlusion &c
  (h) Lacrymal sac—swelling, regurgitation, &c

(8) Conjunctiva (a) Ocular — congestion (conjunctival and ciliary), secretion, phlyctenules, growths, wounds, &c
  (b) Palpebral—congestion, granulations, scars, concretions, ulcers, &c
  (c) Plica semilunaris—displacement in pterygium, growths, &c
  (d) Caruncle—inflammation, granulations, growths, &c

(9) **Cornea** (a) Size—glaucoma, buphthalmia, &c

(b) Curvature—conical buphthalmia, anterior staphyloma, abrasions (*vide* p 85), &c

(c) Surface—corneal reflex, abrasions, ulcers, foreign bodies, &c

(d) Transparency—ulcers, nebulae, keratitis (superficial and deep vascularisation, *vide* p 90), " k p," striate opacity, &c

(10) **Sclerotic** (a) Curvature and colour—myopia, staphyloma, episcleritis, &c

(b) Vessels—ciliary injection, episcleritis, scleritis, &c

(11) **Anterior chamber** (a) Depth—(z) shallow—perforating wound, glaucoma, dislocation of lens, &c , (β) deep —buphthalmia, iridocyclitis, dislocation of lens &c , (γ) irregular—iris bombé, dislocation of lens, &c

(b) Contents—cloudy aqueous, hypopyon, hyphaema, foreign bodies, dislocated lens, &c

(12) **Iris** (a) Colour—muddy in iritis, heterochromia (congenital and in iridocyclitis) atrophy, ectropion of uvea, melanomata &c

(b) Position, especially plane of surface—iris bombé, retraction in iridocyclitis, pseudo glioma, &c

(13) **Pupils** (a) Relative size (*vide* p 92)

(b) Reaction to light—direct consensual maintenance of constriction (*vide* p 93)

(c) Reaction on convergence

(d) Synechiae—anterior and posterior

(14) **Intraocular tension** Increased in glaucoma, iridocyclitis diminished in iridocyclitis, perforation or rupture of the globe, &c

(15) **Central vision** (*vide* p 130)

(16) **Lens** By oblique illumination and the ophthalmoscope

(17) **Vitreous** Opacities fluidity, foreign bodies haemorrhage retinitis proliferans " persistent hyaloid artery &c

(18) **Fundus** (a) Optic disc—blurring of the edges swelling cupping colour crescents, &c

(b) Retinal vessels—size, contour, tortuosity, &c

(c) General view—retinitis, choroiditis, &c

(d) Periphery

(e) Macula

(19) **Field of vision**

APPENDIX II

THERAPEUTIC NOTES

(The strengths of lotions, &c , are given in percentages
1 per cent = gr v to ℥ 1 (approximately))

LIDS

Lotions   3 per cent Sodium bicarbonate
              3 per cent Borax

These are used for dissolving the crusts in blepharitis They may be used
in conjunction with 1 to 2 per cent salicylic acid 1 to 2 per cent resorcin
liquor carbonis detergens (♏ ı —ıv to ℥ ı) &c

Pigments   10 per cent Silver nitrate
              1 per cent Picric acid
              1 per cent Salicylic acid

These are used for ulcerative blepharitis the excess should be removed
with cotton wool

Liquor Tinctorium

This consists of equal parts of crystal violet (0 5 per cent) and brilliant
green (0 5 per cent) in equal parts of alcohol and water

Ointments   2 per cent Ammoniated mercury
              3 per cent Yellow oxide of mercury

These are well rubbed into the lashes for five minutes three times a day
after removing the crusts in ulcerative blepharitis   Alternative prepara
tions are 1 per cent salicylic acid 3 per cent. airol 2 per cent. resorcin
3 per cent ichthyol &c

Triple dye Jelly

This consists of gentian violet 1/400 brilliant green 1 400 and neutral
acriflavine 1/1000   It is used for burns of the lids (v p 641)

CONJUNCTIVA

Lotions   3 per cent Boric acid
              1 in 5000 Perchloride of mercury
              1 in 8000 Oxycyanide of mercury
              1 per cent Mercurochrome
              1 in 1500 Acriflavine
              1 in 2500 Metaphen
              1 in 2500 Hexyl resorcin

These are used as cleansing lot ons in acute conjunctivitis and have slight
antiseptic properties   they should be mixed with an equal quantity of hot
water as a rule   Mercury compounds occasionally cause severe dermatitis

2 per cent Borax.
This combined with dilute hydrocyanic acid (1 per cent.), relieves irritation in mild conjunctivitis

1 per cent Alum
¼ per cent Zinc sulphate or chloride
These are astringent lotions used in chronic conjunctivitis. Zinc lotion is specially indicated in angular conjunctivitis (q v). Alternative preparations are 1 per cent tannin, ⅓ per cent copper sulphate, 3 to 6 per cent sodium sozoiodol, ¼ per cent zinc sulphocarbolate, &c.

1 per cent Quinine hydrochloride or sulphate
This is recommended for membranous conjunctivitis. The least possible amount of dilute sulphuric acid should be used to dissolve the salt if the sulphate is used

Pigments **2 per cent Silver nitrate**
This is used in acute conjunctivitis. Alternative preparations are 10 to 40 per cent argyrol, 10 to 40 per cent. protargol 5 to 10 per cent argen tamin &c , these are probably not so effectual (*vide p* 154)

2 to 4 per cent Perchloride of mercury in glycerin and water
This is occasionally used in trachoma. it must not be allowed to touch the cornea. Iced compresses should be applied immediately *after* the application is made

Drops The astringent lotions may be used in the form of drops. Silver nitrate should not be ordered in this form on account of the staining which may occur from prolonged use

2 to 4 per cent Cocaine hydrochloride
This is used for producing local anaesthesia. Conjunctival and corneal anaesthesia is complete after instilling four drops at intervals of five minutes. During the intervals the eyes should be kept closed on account of the desic cating action on the corneal epithelium. In intraocular operations one drop should be instilled into the opposite eye (*vide* p 488). It must not be used for hypodermic injection, but must be replaced by the less toxic novocain

1 per cent Pantocain
This derivative of novocain has largely replaced the use of cocaine, 2 per cent solution giving an even stronger and more prolonged anaesthesia than 4 per cent cocaine. It does not dilate the pupil nor dull the corneal epithelium.

2 per cent β Eucain hydrochloride
2 per cent Alypin
These may be used instead of cocaine. They do not dilate the pupil and are less toxic than cocaine but they cause considerable smarting

1 to 10 per cent Dionin
This causes intense oedema of the conjunctiva after prolonged use the reaction is slight or absent. The patient complains of a burning sensation which quickly disappears. The first application should be made by the surgeon. The drug stimulates the lymph flow, and has therefore been recommended in a large variety of cases, *e.g*, corneal nebulæ, scleritis, iridocyclitis &c. It must be used with caution

Subconjunctival Injections —These have been recommended for the same

reason as dionin and their value if any is still unproved   Many solutions
have been used   Sterile 2 to 10 per cent salt solution is the best   the others
probably possess no advantage, and are in some cases liable to cause necrosis
The injection is made with a hypodermic needle under the bulbar conjunctiva
as far back as possible above the globe   There is considerable reaction and
pain   Not more than 5 to 10 minims should be injected every other day

Ointments   Vaseline
15 per cent Boric acid ointment
These are used to prevent the lids from sticking together and thus causing
retention of secretion

1 to 3 per cent Yellow oxide of mercury
This is used as a stimulant and antiseptic in phlyctenular and chronic
conjunctivitis

CORNEA

Lotions   The same collyria as for conjunctival conditions
are used as cleansing and antiseptic measures   The astringent
collyria are seldom indicated

Pigments   1 per cent Silver nitrate
This is indicated in some cases of marginal ulceration (*vide* p 223)

Pure carbolic acid
This is used as a cauterising agent in hypopyon ulcer (*vide* p 217)

Drops   These are the ordinary mydriatics and cycloplegics
and in rare cases miotics (*vide infra*)

Dionin or subconjunctival hypertonic saline injection is sometimes used
with a view to clearing corneal nebulae   Two per cent fluorescein in 3 per
cent bicarbonate of sodium solution is used for staining ulcers and abrasions
for diagnostic purposes

Ointments   These are the same as for conjunctival
conditions

2 to 5 per cent iodoform xeroform or airol ointment may be used in
corneal ulceration   Dionin (5 to 10 per cent) and mydriatics may be
prescribed in ointment form   1 to 5 per cent yellow oxide of mercury
ointment is used in gradually increasing strength to aid in the clearing of
nebulae and the opacity of interstitial keratitis , it may be combined with
dionin

MYDRIATICS AND CYCLOPLEGICS , MIOTICS

Mydriatics and Cycloplegics (*vide* p 62)   ½ to 1 per cent
Atropine sulphate   ¼ to ½ per cent Hyoscine or Scopolamine
hydrobromide   ¼ to ½ per cent Duboisine sulphate   ½ to 1
per cent Daturine sulphate

These are used as drops or ointment in corneal ulcers, iritis indocyclitis
&c   Atropine is used generally, the others being employed as substitutes
when atropine causes irritation   Hyoscine occasionally causes delirium and
should be watched

1 per cent Homatropine hydrobromide, with or without
2 per cent cocaine hydrochloride

1 to 2 per cent Euphthalmine hydrochloride

These are used for investigation of refraction and for ophthalmoscopic
examination, also for the diagnosis of synechia (vide p 260) and occasionally for the diagnosis of increased tension (vide p 260) For refraction
solutions of the same strength of the bases in castor oil are more certain in
their action

1 per cent Paredrine

This dilates the pupil with very slight effect on accommodation

Laevoglaucosan is a more powerful mydriatic than atropine

It consists of 2 per cent laevo-rotatory deltaenphrin with 2 per cent
methylaminoacetopyrocatechol Two drops are repeatedly instilled at
intervals of fifteen minutes It is an expensive drug

2 per cent Cocaine hydrochloride

This is used occasionally in old people as a mydriatic for ophthalmoscopic
purposes, being less likely to raise the tension, the effect being readily
counteracted by miotics

"Mydricain" The most powerful mydriatic effect has been
obtained by subconjunctival injection of a mixture of atropine,
cocaine and suprarenin

Each 5 minim dose of mydricain consists of atropine sulphate gr 1/50,
cocaine hydrochloride gr 1/10 and laevo rotatory suprarenin gr 1/600,
with sodium chloride gr 1/80 and chlorbutol gr 1/120, in sterilised water
(Flynn, *Brit Jl of Ophthal*, XVII, p 298 1933)

Miotics (vide p 63) ½ to 1 per cent Pilocarpine hydrochloride ¼ to 1 per cent Eserine or Physostigmine sulphate or
salicylate, with or without 1 per cent cocaine hydrochloride

These are used in glaucoma (q v), and occasionally in other cases (vide
p 223) The effect of cocaine is to assist the absorption of the other drug

0 75 per cent Doryl (carbaminoyl cholin) is more active than 2 per
cent pilocarpine and less active than 1 per cent eserine and may be used
as a substitute for these miotics

Hot Bathings

Much better than the usual hot fomentations is the method
of hot bathing used at Moorfields Eye Hospital A pad of
cotton wool is tied into the bowl of a wooden spoon The wool
is dipped into a bowl of boiling water, and is then approximated to the closed eye As soon as it has cooled sufficiently
it is brought into contact with the closed lids As soon as it
ceases to feel hot the wool is again dipped in the hot water
and the process repeated The bathing is continued for
ten to fifteen minutes, and then a pad of dry warm cotton
wool is bandaged over the eye The hot bathings may be
repeated frequently

THE TREATMENT OF SYPHILITIC AFFECTIONS

In cases of suspected syphilitic disease of the eye the possibility of demonstrating the presence of the spirochaete should be borne in mind More generally useful is the application of Wassermann's test, for which the aid of a bacteriologist is advisable No anti syphilitic remedies should be used until the test has been applied When the lesion is probably syphilitic the patient should be brought rapidly under the influence of mercury and iodine or arsenic compounds Mercury may be given by inunctions, intra muscular injections, or intravenous injections supplemented if necessary by administration by the mouth Inunction is generally employed, and for this purpose the oleate of mercury is preferable to the ordinary mercury ointment Intramuscular and intravenous injections require special technique Intravenous injection of salvarsan ("606") N A B, or its equivalent is sometimes remarkably successful, especially in the acute stage of syphilitic manifestations Substitutes for the ordinary iodides as sajodin or iodoglidine tablets (1 to 3 i e, 7 to 15 gr three times a day) iodipin (30 gr of 25 per cent = about 10 gr of potassium iodide), &c

SULPHONAMIDE THERAPY

The dramatic effect of sulphanilamide in puerperal fever has led to extensive use of sulphonamides in infective conditions A combination of chemotherapy with active immunisation may prove particularly effective, one or two doses of vaccine being administered at 2 to 5 day intervals after the sulphonamide has been given The drugs in common use are sulphanilamide, sulphapyridine and sulphathiazole

Sulphanilamide (Syn —Prontosil album, Streptocide, &c) is used as a prophylactic in wound infection, and in the treatment of haemolytic streptococcal infections, erysipelas, cellulitis, follicular tonsillitis, otitis media meningococcal "carriers," and urinary infection with B coli It is unreliable against all pneumococci except type III, and has little effect on staphylococci It reaches maximum concentration in the blood, aqueous and vitreous, in six hours For prophylaxis a first dose of 1 5 gram (three tablets), dissolved in hot citric acid (1 per cent) or lemon juice, is given One tablet (0 5 gm) is given two hours later and repeated at four hourly intervals for four days In order to delay absorption, the tablets should not be crushed The dosage should not exceed 4 5 gm the first day and 3 gm on subsequent days, up to a total of 13 5 gm Sulphanilamide powder (6 to 16 gm) may be dusted over wounds other than those of the conjunctiva and cornea , or a spray may be used For treatment, a first dose of 2 gm (4 tablets), dissolved in hot citric acid (1 per cent) or lemon juice, is given Two uncrushed tablets (1 gm) are given two hours later and repeated at four hourly intervals for two days, after which the dose is gradually reduced The interval between doses should not exceed six hours for several days Small doses, e g , 3 gm a day, should be given for three or four days after the clinical condition has become satisfactory The duration of treatment should not exceed ten days, and the total dosage seldom more than 35 gm In streptococcal infections of moderate severity the total dosage in the first 48 hours need not exceed 4 to 6 gm a day

Sulphapyridine (Syn —M & B 693) is of value in the treatment of gonorrhoea, cerebrospinal meningitis, pneumonia and pneumococcal infections, staphylococcal septicaemia and gas gangrene The dosage for adults is the same as for sulphanilamide they should be on a milk diet, and constipation should be avoided The reduced dosage for infants suffering from ophthalmia neonatorum is half of a 0 125 gm tablet four hourly before each feed The maximum time required is 60 hours , should there be marked improvement

earlier the drug may be stopped in 48 hours   This treatment has been very successful in all cases

Sulphathiazole is less toxic than sulphanilamide and sulphapyridine, and is used for the treatment of staphylococcal infections

SERUM AND VACCINE TREATMENT

In diphtheritic conjunctivitis antitoxic serum should be used   The indications for other sera and vaccines in the domain of ophthalmology are much less precise   Antipneumococcic serum for the treatment of hypopyon ulcer has proved disappointing   Antigonococcic serum has been advocated in ophthalmia neonatorum and gonorrhœal ophthalmia   In desperate cases of septic infection of the eye after perforating wound, accidental or operative, a polyvalent serum may be employed, or if possible a vaccine made from a culture taken from the eye   oral administration of antidiphtheritic serum has been recommended in these cases   The vaccine treatment of tuberculosis is much used   Many obscure pathological conditions in the eye suggest the possibility of a tuberculous origin.   Diagnosis may be facilitated in some, probably a minority of cases, by the application of von Pirquet's cutaneous test   Wolff Eisner and Calmette s conjunctival reaction should not be used   Occasionally, as in conjunctival tuberculosis, it is possible to place the diagnosis beyond doubt by inoculation experiments on animals , the incubation period, however, is lengthy (20 to 30 days)   Tuberculin treatment is best carried out by a bacteriologist familiar with the technique

SHOCK THERAPY

Subcutaneous injection of foreign proteins usually produces considerable febrile reaction and sometimes improvement in obscure or recalcitrant inflammatory eye diseases   Milk is generally used   It should be boiled twice for 4 minutes each time   The initial dose is 5 c c injected intramuscularly , the dose may be increased to 10 or 12 c c (1 c c for infants under 1 year, 2 c c up to 5 years and 3 c c up to 10 years of age)   Three or four doses are given at 2 or 3 day intervals   It is a wise precaution to give a preliminary injection of 1 c c to guard against anaphylactic shock   Typhoid paratyphoid vaccine is also used intravenously and has been effective in sympathetic ophthalmia   Antidiphtheritic serum is good but the danger of anaphylactic shock on repetition must be guarded against

The general reaction in shock therapy is at first low temperature with rigor, slow pulse and nausea, followed by high temperature, rapid pulse and leucocytosis.   There is local erythema and tenderness   The local reaction is shown by hyperæmia and inflammatory changes, accompanied by relief of pain

CARE OF INSTRUMENTS

Ophthalmic instruments should be kept in an air tight glass cabinet, or when not constantly in use in velvet lined cases

All instruments should be sterilised before use by boiling in 3 per cent. sodium carbonate solution (not bicarbonate), made with *distilled* water   This procedure does not impair the cutting edges, but knives and scissors should not be boiled more than three to five minutes   this is amply sufficient if the surfaces are bright and free from tarnish, as they ought to be   If distilled water cannot be obtained the cutting instruments should well soaked in pure carbolic acid before being transferred to the dish

The instruments should be removed from the steriliser *immediately* before

operating and used dry In no case must *instruments be immersed in bone lotion* since it tarnishes the steel

It is, however, much safer to use the instruments dry It is almost impossible to sterilise the skin of the hands efficiently, and if the instruments are wet fluid from the fingers is liable to run along them into the eye The points of knives &c, should be dipped in sterile saline immediately before use to facilitate their passage through the tissues

The surgeon should wear a sterilised gown and also a mask, containing a layer of cellophane covering the nose and mouth for all intraocular operations

APPENDIX III

REQUIREMENTS OF CANDIDATES FOR ADMISSION INTO THE PUBLIC SERVICES

COMMISSIONS IN THE ARMY

The following standards are used at present —

Standard 1   Unaided vision is not less than 6/6 in one eye and not less than 6/9 in the other

Standard 2   Unaided vision is less than in Standard 1 but is either not less than 6/12 in each eye or is not less than 6 6 in the right eye, and not less than 6/36 in the left eye

Standard 3   Unaided vision is less than in Standard 2 but vision can be corrected to at least Standard 2

Note   In those cases where unaided vision is below 6/60 in either eye the men will be referred to an ophthalmologist and where a myopia of more than minus 7 in any meridian is found he will be placed in Standard 7

Standard 4   Unaided vision is less than in Standard 2 and vision cannot be corrected to Standard 2 but can be corrected to at least 6/12 in one eye and to at least 6/36 in the other

Note   This standard includes those men whose left eye is the ' master'' eye and whose vision with or without correction is not less than 6/12 in the left eye, and not less than 6/36 in the right eye

Standard 5   \ the conditions in Standards 1 to 4 cannot be attained but vision can be corrected to at least 6*24 in each eye

Standard 6   \ vision in one eye, with or without glasses, is not less than 6/12 and in the other is less than 6 36 with or without glasses, or has been lost or practically lost and investigation as to the cause of the loss is satisfactory

Standard 7   \ vision is below Standards 1 to 6

COMMISSIONS IN THE ROYAL NAVY

ENTRY STANDARDS OF VISION, OFFICERS R N

	Distant Vision		Near Vision	Colour Vision
CADETS, DARTMOUTH	6/6	6 6	Snellen, D = 0 5 (Jaeger, 1)	Grade I

(a) Limit of hypermetropia permissible (under homatropine)

In the better eye

Hypermetropia, 1 5 dioptre   Simple hypermetropic astigmatism, 0 75 dioptre   Compound hypermetropic astigmatism - the error in the more hypermetropic meridian must not exceed 1 5 dioptre of which not more than 0 75 dioptre may be due to astigmatism

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	Distant Vision	Near Vision	Colour Vision

CADETS, DARTMOUTH —contd

In the worse eye Hypermetropia, 2·5 dioptres Simple hypermetropic astigmatism, 1·0 dioptre Compound hypermetropic astigmatism 2·5 dioptres in the meridian of greater error, of which not more than 1·0 dioptre may be due to astigmatism
(b) Fields of vision to be normal
(c) Glasses are not allowed on duty

	Distant Vision	Near Vision	Colour Vision
CADETS, EXECUTIVE ("Special Entry")	6/6 6/12	Snellen, D = 0·5 (Jaeger, 1)	Grade I

(a)
(b) As for Cadets, Dartmouth
(c)

	Distant Vision	Near Vision	Colour Vision
CADETS, ENGINEERING BRANCH ("Special Entry")	6/9 6/12	Snellen, D = 0·5 (Jaeger, 1)	Grade II

(a) Hypermetropia exceeding 5·0 dioptres (under homatropine) in the meridian of greater error will disqualify
(b) As for Cadets, Dartmouth
(c)

	Distant Vision	Near Vision	Colour Vision
PAYMASTER CADETS ("Special Entry")	6/60 6/60	Snellen, D = 0·6 (Jaeger, 2) with glasses	Grade III

(a) As for Cadets, Engineering Branch
(b) Fields of vision to be normal
(c) Glasses permitted on duty. Distant vision, with glasses, to be not less than 6/6 in one eye and 6/24 in the other eye

	Distant Vision	Near Vision	Colour Vision
ROYAL MARINES	6/12 6/12	Snellen, D = 0·5 (Jaeger, 1)	Grade II

(a) As for Cadets, Engineering Branch
(b) As for Cadets, Dartmouth
(c)

	Distant Vision	Near Vision	Colour Vision
MEDICAL OFFICERS, DENTAL OFFICERS, NURSING SISTERS	6/60 6/60	Snellen, D = 0·6 (Jaeger, 2) with glasses	Grade II

(a) As for Paymaster Cadets
(b) A gross defect will disqualify
(c) As for Paymaster Cadets

	Distant Vision	Near Vision	Colour Vision
INSTRUCTOR OFFICERS, SCHOOLMASTERS, CHAPLAINS	6/60 6/60	Snellen, D = 0·6 (Jaeger, 2) with glasses	Grade III

(a)
(b) As for Medical Officers
(c)

Squint, deformity or any chronic disease of the eyes or eyelids will disqualify for entry into any Branch

The standard of distant vision must be attained without glasses, and except where otherwise stated, visual acuity, with glasses, must be not lower than 6/6 in each eye tested separately For certain Branches (noted above), glasses may be used during the test of near vision

Colour Vision Details regarding testing and grading will be found in Medical Research Council, Special Report Series, No 185 (H M Stationery Office) Candidates for Branches in which the wearing of glasses on duty is permitted may use them for the colour vision test

EYE EXAMINATION FOR FITNESS FOR FLYING
(ROYAL AIR FORCE AND CIVIL)

These standards are peace-time standards and are subject to alteration during wartime

Previous History Enquiry should be made as to the use of glasses, and if worn, for what cause   Details in respect of any inflammatory condition of the globe, lids or conjunctiva should be recorded as well as, in candidates, information concerning ability to see at night

Visual Acuity The examination will be conducted with well illuminated standard test types at a distance of 20 feet   The candidate must read the test types without hesitation   The standard of visual acuity without correcting glasses for service in the Royal Air Force is —

Distant vision each eye, $V = 6/6$ The eye specialist, however, may, at his discretion, recommend acceptance when the visual acuity is equal to 6/9 (for Short Service Commissions 6/12) in each eye, provided that such vision is correctable by glasses to 6/6 in each eye

For private flying (" A " Licence), and for navigators (" B " Licence), a certain allowance is made and correcting glasses are allowed to be worn provided a degree of visual acuity can be attained, with or without glasses, equal to at least 80 per cent of the normal visual acuity for each eye taken separately, or 90 per cent for one eye and 70 per cent for the other

The same standard *without* glasses holds for pilots for " B " Licence (*Note* Visual acuity is equal to 100 per cent normal when at a given distance—20 feet in Great Britain—the letters of the standard type subtend an angle of five minutes   The easiest way to test 80 per cent normal vision is to get the applicant to read standard 6/6 type at a distance of 16 feet   Similarly, 80 per cent vision is obtained with 6/6 type at 18 feet and 70 per cent at 14 feet   In other words, every 2 feet nearer the type represents a diminution of 10 per cent in visual acuity

Hypermetropia No candidate, generally speaking, will be passed who reveals a manifest hypermetropia (that is, hypermetropia revealed without the use of a mydriatic) of + 2 00 D Sph or over   The reason for this ruling is that the continued effort to focus rays correctly on the retina is apt to induce a tonic action of the ciliary muscle, and also of the internal recti muscles, since the latter are concerned in the convergence of the eyeballs that normally takes place when an object is viewed with both eyes at close range   This tonic action produces errors of judgment of distance in flying   In addition, under the effects of high altitude tonus of accommoda tion is liable to occur, so that a pilot cannot see his instruments clearly and will also be liable to make a bad landing   Furthermore, in this condition of hypermetropia—apart from flying—the eye is likely to become fatigued by

conditions such as close work, the effects of sunglare, and the after effects of acute infections, in particular of influenza, sandfly fever and malaria With advancing age accommodative power is lessened and latent hypermetropia may become manifest

Muscle Balance and Visual Judgment These play an even greater part in accurate flying than does visual acuity The principal factors which necessitate correct visual judgment in flying are :—

    (i) Immediately the aeroplane loses touch with the ground, the pilot loses the one known definite quantity necessary in the judgment of distance to which he has always been accustomed, namely, contact with the ground

    (ii) All verticals are more or less foreshortened and, therefore, the size of known objects will be varied from those of previous experience

    (iii) Shadows of objects will be viewed from a totally different aspect

    (iv) The speed at which the pilot is travelling is greater than any he has ever experienced It may be taken as generally true that the faster an aircraft flies in the air the faster is its landing speed Speed is often the last straw in a borderline judgment case

Ocular Muscle Balance It has now been proved beyond argument that lack of true ocular muscle balance is the most common cause of error in judgment in bringing an aircraft to the landing ground It has been shown that Exophores (those suffering from external latent deviation) tend to flatten out their aircraft too early, having judged the ground to be nearer than it actually is, conversely, Esophores (those suffering from internal deviation) are inclined to fly into the ground In contra-distinction to these cases in which the error is ' perceptive" there are certain other bad landers " in which the fault is essentially " effective" due to a generally defective neuro muscular co ordination The pilot with defective visual judgment but relatively good power of performance must be sharply differentiated from the pilot with relatively good visual judgment but poor power of performance (' heavyhandedness ')

Tests for Ocular Muscle Balance Four tests are employed in the following order :—

    (i) The Convergence Test
    (ii) The Cover Test
    (iii) The Red Green Test
    (iv) The Bishop Harman Diaphragm Test

Convergence Test (i) By convergence power is meant that faculty of eye movement, found normally, which enables an individual to exercise single vision binocularly at very near range Its retention demonstrates the presence of reserve forces of co ordination, and a capacity to resist fatigue, the loss, on the other hand, a lack of such reserve force and an early predisposition to fatigue

    (ii) The test is carried out as follows :—Hold a pencil about a foot from the eyes of the subject under examination , see that the point is accurately between the eyes and on a level with the root of the nose Tell him to fix the point and then move it directly towards him observing what happens to the eyes as they converge The following results may occur :—

    (a) Both eyes may converge fixing the pencil until it gets within an inch or two from the root of the nose, indicating no want of convergence Record distance in inches

    (b) One or other eye ceases to fix the object and may wander out, or both eyes fail to keep up fixation The subject may even resist by

throwing back his head and complain either that it hurts him to follow the pencil or that he sees double In such cases, convergence is defective. Record in inches the distance at which such lack of convergence manifests itself

(m) Convergence power is estimated by giving the following values :— 2 inches or under, very good, possibly excessive ; 2 to 3 inches, good ; 3 to 4 inches, fair ; 4 inches and over, poor.

The Cover Test Hold a pencil in front of the subject at about 1 foot from the nose, asking him to look at the point, then cover one eye with a card. Move the pencil from side to side, bringing it finally to the centre and uncovering Repeat the test for the other eye in a similar manner.

A perfectly balanced pair of eyes will remain fixed on the pencil whether one is uncovered or covered, where a movement inwards or outwards on uncovering (latency) shows some lack of balance. Where the eyes are perfectly balanced on uncovering record an " lat., nil."

Where " latency " (lat) is found, the degree of movement, convergent (con) or divergent (div) and the speed of return to normal alignment is important A movement of less than 30 degrees is recorded as " slight " (sl), or more than this as " marked " (mkd). The return to normal alignment, " recovery " (rec) may be " rapid " (rpd), " moderate " (mod), " slow " (sl), or " by stages," *i e* , jerky, and should be recorded as such. In some cases there may be an appreciable interval before recovery starts, this should be noted as " lag," or there may be no recovery of alignment until the eye is again directed to the object (*e g.*, by covering the other eye) Record this as Rec nil "

To recapitulate, record no movement or latency, as, perfect balance as lat nil " Record movement as " Sl or mkd. lat div, or con." Recovery therefrom as " Rapid, mod slow, by stages, or nil " A record of the test may, therefore, read :—

Sl lat div rec rpd "
" Mkd lat con rec sl."
Mkd lat div. lag mod "
" Mkd. lat con rec nil "

The Perl Green Test The basis of this test is that a suitable tint of red glass in one eye will cut out any rays of light coming through a green glass and, *vice versa*, green glass in the other eye will cut out red rays. In a black box containing a lamp, a vertical slot ⅜ inch wide by 8 inches long, is glazed in the upper 2¼ inches with red and in the lower 2¼ inches with green. The person under examination—wearing a pair of reversible frames containing red glass in one eye-piece an green in the other—is told to look at the slot illuminated from behind and asked to state what he sees :—

(1) (*a*) The two lights in their proper position (*i e* alignment of visual axes and correct ocular muscle balance) ; (*b*) definite displacement up or down and or right or left (*i e*, hyper or hypo- and or eso- or exo phoria) ; (*c*) one or both may wander from original position and back again (*i e.*, tendency to aphoria, but with some or full power of correction)

(n) At first two lights then an occasional disappearance of one of them, either the same one all the time, or the two alternately (*i e.*, mastery of one eye, either continuous or alternating, with neglect of vision by the other)

(m) Either colour singly, but never the two together (*i e.*, alternate perception of the object with suppression of the image of the other eye)

(It may happen that the two colours will be superimposed and fused into one image reversal of the frame obviates this difficulty, as the colours will

APPENDIX III

then be separated) The nature and amount of displacement indicate the quality and quantity of the heterophoria thus revealed A true exophoric case may give a temporary exophoric displacement owing to over compensation but, as fatigue sets in, the image passes through the orthophoric to the exophoric position

The *Bishop Harman Diaphragm Test* (1) This is a direct measure (capable of being standardised) of the power to maintain binocular vision under an increasing disability and being a test at average working distance, it allows the influence of bad habits acquired from certain occupations to be demonstrated The cardinal principle of the test is the estimation of the relative capacity of the subject tested to maintain an even ocular muscle balance (and, therefore binocular single vision) under increasing disability by progressively diminishing the overlap of the binocular fields of view
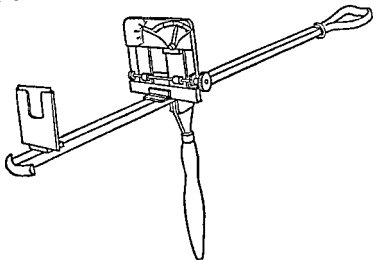
BISHOP HARMAN DIAPHRAGM INSTRUMENT

further, the test aims at so standardising the conditions as to produce a measurable expression of this capacity

(11) The instrument consists of a rod, one end of which carries an end piece shaped to fit the upper lip to which it may be pressed by means of a handle fixed below the rod At the other end, 44 cm away, is a vertical card hol ler in the plane at right angles to the rod Between these, 11 cm from, and parallel to the card holder, is a diaphragm in which a rectangular aperture is cut, through which the subject views the test card The aperture is capable of being widened or narrowed at will by means of two shutters one on either side of the opening, worked by a right and left handed screw, which is rotated by means of a milled head Movement of the shutters operates a pointer registering on a quadrant scale, which can itself be adjusted to the widely varying pupillary distances of individual subjects With wide open diaphragm, all the figures on the test card—say 1, 2, 3, 4, 5, 6, 7—can be seen by both eyes together, but as the edges of the diaphragm move towards each other, this binocular overlay becomes more and more reduced, until finally there remains nothing in sight which is common to the two eyes

(11) In performing the test, the subject is asked to state precisely what

happens to the figures when the size of the aperture is gradually diminished For instance, he may state that :—

(a) The figures at one or other end of the card begin to disappear—indicating suppression of one or other image

(b) The middle figures tend to crowd together and mix up—indicating esophoria

(c) The figures divide, and the centre figure tends to duplicate or a black bar appears between them—indicating exophoria

(d) Some of the figures deviate to a higher or lower level—indicating hypophoria or hyperphoria

(e) A black bar appears, obliterating the middle figure, but the rest remain in the proper relative positions—indicating that the driving has been entirely cut down, and that there is a negative gap which is represented by blackness , in such an instance the reading will be below zero, and will indicate a perfect control of balance

It has been found that a reading of " 3 " on the arbitrary scale is a " border line " one and that " 5 " is bad   First-class " landers " usually give a reading of zero or below , average " landers " zero to " 2 ", doubtful " landers '" 2 ' to 3 ", whilst those giving readings of " 3 " to " 5 " or more fall generally into the category of bad ' landers "

The Visual Fields   Both eyes must have good fields of vision as tested by hand movements   Normal fields of vision are both good and necessary for flying, because —

(i) The pilot requires to obtain the widest possible view of aircraft and other objects in his proximity

(ii) It depends mainly upon the vision of the peripheral fields for judgment of the pace of his aircraft in relation to laterally placed stationary objects

(iii) The grey horizon (false horizon) at night is best perceived by the rod elements of the peripheral fields

(iv) There are certain ocular diseases which reveal alterations in the peripheral fields, while normal central vision is retained , to detect these, the rough test by hand movement is, generally speaking, quite sufficient

Colour Vision   This must be normal, as normal colour perception is requisite in navigation and landing, owing to the use of coloured lights as signals

<center>VISUAL STANDARDS—SERVICE AND CIVIL</center>

The present visual standards for flying *personnel*, both Service and Civil, are as follows —

ROYAL AIR FORCE

(a) *Cadets for Cranwell and candidates who are to receive immediate permanent commissions*
Visual acuity 6/6 without the aid of glasses each eye   6 9 each eye considered under special circumstances if the defect is correctable to 6/6 by glasses   Manifest hypermetropia not to exceed + 2 25 dioptres spherical

(b) *Candidates who are to receive short-service commissions*
The limit here is extended to 6/12 either eye without glasses,

APPENDIX III

correctable by glasses to 6/6 If the refractive error is myopic in character the prospect of acceptance is reduced

Ground Branches 6/00 both eyes correctable to 6/9

CIVIL 'B' LICENCE *Pilots carrying passengers for hire or reward* (Under the International Convention for Air Navigation)

Initial examination

Visual acuity without correcting glasses must not be lower than 80 per cent in each eye (approximately 6/7 5) or 90 per cent in one eye and 70 per cent in the other eye

Renewal examinations

New standards are being made which will permit of 70 per cent vision in each eye, provided the candidate has flown 1,000 hours or 50 per cent in each eye when 2,000 hours have been flown Glasses or flying goggles must be worn in the latter case

CIVIL "A" LICENCE *Pilots of private machine*

Candidates must be able to read *with the aid of spectacles* the same distance types as for " B" Licence candidate At present there is no limit to the primary defect A defect of 6/00 each eye will, however, come into force shortly and disqualify

COLOUR VISION This is divided into two groups :—

Royal Air Force

    (a) Colour defective, safe

    (b) Colour defective, unsafe

(a) *Colour defective, safe* *Royal Air Force* When tested by the Anomalous Trichromaticism can be accepted When tested by the Ishihara colour plates such a candidate must read accurately plates 1, 7, 0, 12 and 13 The plates will be found numbered in small print below the colour scheme

(b) *Colour defective, unsafe* *Royal Air Force*

Candidates who misname the colours red and green in any combination on the lantern or who fail to name accurately the Ishihara charts noted above are rejected

Civil pilots B *Licence*

Colour vision must be normal both with the lantern and with the Ishihara charts (or other colour book)

" A' *Licence*

Colour defects cause the candidate to be restricted to daylight flying only

OCULAR MUSCLE BALANCE

Royal Air Force

(a) The red green test or the Maddox rod should not show deviation at 20 feet exceeding 2 prism dioptres of exo , 3 prism dioptres eso , or 1 prism dioptre hyperphoria

(b) The reading on the ocular poise scale on the Bishop Harman diaphragm should not be outside 5 and the convergence should be no worse than 4 inches The cover test response should be reasonably quick

" A" and " B" *Licence*

Binocular vision, ocular poise, and the field of vision of each eye must be normal

Masters and Mates of the Mercantile Marine

I.—Letter Test

1 *Letter Test to be Passed First.*—The first test which the candidate is required to undergo is the letter test

2 *Apparatus Used.*—The letter test to be used for all candidates is that conducted on Snellen's principle by means of sheets of letters

3 *Standard of Vision Required.*—With the exceptions indicated below (*see* paragraph 6), every candidate will be required to read correctly nine of the twelve letters in the sixth line and eight of the fifteen letters in the seventh line of a test sheet placed in a good light at a distance of 16 feet from the eye

4 *Method of Testing.*—The test sheets should be hung on the wall, in a *good light but not in direct sunlight*, at a height of five or six feet from the ground The candidate should be placed at a distance of exactly 16 feet from the sheets, and exactly opposite them This distance should be carefully measured, and should never in any circumstances be varied

One of the sheets should then be exposed and the candidate should be asked to read the letters on each sheet beginning at the top and going downwards Any mistakes which he makes should be carefully noted If then it is found that he has read correctly at least nine letters in the sixth line and eight letters in the seventh line of a sheet the candidate may be considered to have normal vision and should be marked passed " in the appropriate column of the form of application (Exn 2 or Exn 2a, as the case may be)

5 *Passing or Failure.*—If at the conclusion of the test the candidate is found to reach the required standard he may be considered to have passed, and the Examiner should proceed with the lantern test unless the candidate holds a certificate of competency If the candidate fails to reach the standard required for the certificate entered for he should be tested with at least four sheets and the Examiner should fill in a Form Fxn 17b, the number of mistakes made on each line of each sheet and explain to the candidate the alternatives mentioned in paragraph 3t (d)

Failure to pass the letter test is due to some defect in form vision, and the Board are advised that such defects are sometimes curable Whenever, therefore, a candidate fails to pass this test the Examiner should advise him to consult an ophthalmic surgeon with a view to ascertaining what is the nature of the defect in his form vision, and whether it is curable

6 *Lower Standard Required in Certain Cases.*—Candidates who are in possession of certificates obtained before January 1st 1914 may be regarded as passing the letter test if they can read correctly with both eyes at least five of the eight letters in the fifth line of a test sheet

7 *Tests to be Varied.*—The Examiner should take care, by varying the order of the test sheets and by every other means in his power, to guard against the possibility of any deception on the part of the candidate

8 *Result of Examination to be Reported.*—The result of every examination in the letter test should be reported in the case of a candidate for a certificate of competency, to the Registrar General of Shipping and Seamen on Form Exn 2, and to the Principal Examiner of Master and Mates on Form Exn 14 and, in the case of a candidate for the sight tests only, to the Registrar General of Shipping and Seamen on Form Exn 2a

II.—Lantern Test

9 *Apparatus.*—A special lantern and a mirror have been provided for this test The lantern should be placed directly in front of the mirror, so

that the front part of the lantern is exactly ten feet from the mirror. Care should be taken that the lantern is properly placed, that is to say, the lights reflected in the mirror must show clearly when viewed from the position of the Candidate on the left of the lantern The Examiner should always satisfy himself that these conditions are fulfilled before commencing the examination

10 *Darkness Adaptation* —It is essential that a Candidate should be kept in a room which is either completely or partially darkened for at least a quarter of an hour before he is required to undergo his test

Before the examination commences the Examiner must satisfy himself that the room in which it is conducted is so darkened as to exclude all daylight.

11 *Method of Testing* —The lantern supplied for the examination is so constructed as to allow one large or two small lights to be visible, and is fitted with 12 glasses of three colours—red, white and green   At the commencement of the examination the Examiner should show to the candidate a series of lights through the large aperture, and should require him to name the colours as they appear to him   Care should be taken in showing the white light to emphasise the fact that this light is not a pure white   If a Candidate makes a mistake of calling this light " red," a proper red light should be shown immediately after and the Candidate's attention directed to the difference between the two

After a series of lights through the large aperture has been shown, the Examiner should make a complete circuit with the two small apertures, requiring the Candidate to name the colours of each set of two lights from left to right To prevent any possibility of the order in which the lights are arranged from being learnt, the Examiner should at least twice in each circuit go back a varying number of colours

A record of any mistakes made with either the large aperture or the two smaller apertures should be kept on Form Exn 17b in accordance with the instructions thereon   In all such cas s the mistakes made by a candidate in the letter test should also be recorded on the form

12 *Passing or Failure* —If a Candidate with either the large aperture or the two smaller apertures of the lantern mistakes red for green or green for red, he should be considered to have " failed " in the lantern test

If the only mistake made by the Candidate with the lantern is to call the white light   red," and if after his attention has been specially directed to the difference between the two he makes no further mistake of this nature he should be considered to have passed in the lantern test

If a Candidate makes any other mistake with the lantern, ι e , if he calls white " red " repeatedly or red " white " at all, or confuses green and white, his case should be submitted to the Principal Examiner of Masters and Mates and he should be told that the decision as to whether he is passed or failed, or must undergo further examination will be communicated to him in due course   Pending the receipt of the Principal Examiner's instructions such a Candidate should only be allowed to proceed with the remainder of the examination for a Certificate of Competency on the express understanding that the latter examination will be cancelled in the event of failure in the Sight Tests

13 *Further Examination and Appeals* —If in the cases covered by the preceding paragraph the Principal Examiner decides that a further examination is necessary, arrangements will be made for a special examination to be held in London

If, however, on the report of the local Examiner the Principal Examiner decides that the nature of the mistakes made shows conclusively that a Candidate's sight is so defective as to render him unfit to hold a Certificate, the Candidate shall be considered to have failed

In cases where, upon the report of the local Examiner, a Candidate is failed by the Principal Examiner, as well as in the cases covered by paragraph 12, the Board will be prepared to allow a Candidate who is dissatisfied with this decision to appeal for a special examination in London subject to the conditions set out in paragraph 31 (*f*) (*g*) and (*h*)

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